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As described in Section 1, this Section 7 Consultation is being conducted under the guidance of the Executive Committee, established by the 1997 MOU. The Executive Committee has defined the environmental baseline as conditions that existed before the MOU was signed on December 31, 1997. NOAA Fisheries defines the environmental baseline in a Section 7 Consultation as:

> *…an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area* (USFWS and NMFS 1998).

The environmental baseline provides the foundation for developing proposed changes in operations to benefit listed fish species in the Russian River watershed. Understanding existing conditions is crucial to evaluating the potential effects of the proposed project on listed salmonids.

This section describes the regional setting within the Russian River watershed. It describes the historical and existing environment within the watershed and the status of the listed species and their life-histories. USACE, SCWA, and MCRRFCD facilities and operations under environmental baseline conditions are described in Section 3.

Section 2.1 includes information on hydrology, dams, local land uses, historical channel dynamics, habitat, and water quality. Knowledge of the basin's hydrology is critical to understanding both historic and current conditions. The regional setting under baseline conditions includes a wide range of human activities, and ongoing changes in these activities can exacerbate the impacts of non-project activities on listed fish species.

Section 2.2 describes the biological resources in the watershed and physical habitat conditions. Information on the species distribution, abundance, and other factors necessary to their survival is included as background for the analyses to be presented in the BA. Results of biological monitoring conducted within the watershed, as well as genetic studies, are presented.

2.1 RUSSIAN RIVER WATERSHED

2.1.1 WATERSHED OVERVIEW

California's Russian River drains a watershed of nearly 1,500 square miles centered 60 miles northwest of San Francisco, and empties into the Pacific Ocean near Jenner (Figure 2-1). The watershed is bordered on the west by the Coast Range and on the east by the Mayacamas Mountains, with the Sonoma Mountains occurring in the southern part of the watershed. Geologically, the area is characterized by northwest-trending mountain ranges and intervening alluvial valleys. Hills and mountains comprise 85 percent of the basin, and valleys make up the remaining 15 percent. Unstable Franciscan lithology underlies most of the mountainous regions, and landslides are common. The Russian River flows southward from its headwaters through small valleys and past the cities of Ukiah, Hopland, and Healdsburg before turning west at Mirabel Park. Joining the river near that point are flows from Mark West Creek and Laguna de Santa Rosa, which drain much of the southern portion of the basin. From Mirabel to the Pacific Ocean, low mountains along both banks confine the river for 22 miles. Major tributaries of the Russian River include the East Fork, Big Sulphur Creek, Maacama Creek, Dry Creek, and Mark West Creek/Laguna de Santa Rosa.

Lying within a region of Mediterranean climate, the watershed is divided into a fog-influenced coastal region and an interior region with hot, dry summers. The basin-wide mean annual precipitation is 41 inches, with a range of 22 to 80 inches (USACE 1982). The greatest precipitation occurs at high elevations and in coastal mountains near Cazadero, while the lowest precipitation falls in the southern Santa Rosa Plain (USACE 1982). Approximately 93 percent of the annual runoff occurs from November to April (USACE 1986a, 1986b) during Pacific frontal storms.

Upstream from the East Fork confluence, the mainstem Russian River is uncontrolled by dams and drains an area of 100 square miles to the north and northwest. The East Fork Russian River drains an area of 105 square miles to the northeast of the Forks, but is controlled by Coyote Valley Dam and Lake Mendocino less than 1 mile above the East Fork/mainstem confluence. The East Fork Russian River receives interbasin transfers of water from the Eel River via the PVP.

2.1.1.1 Potter Valley Project

The PVP diverts water from the Eel River watershed through a tunnel to a powerhouse in Potter Valley, where it produces hydropower, and then discharges the used water to the East Fork Russian River above Lake Mendocino. This discussion of the PVP is provided solely as background information for this BA. Neither USACE nor SCWA controls operation of the PVP.

The PVP is comprised of Scott Dam and Lake Pillsbury, Cape Horn Dam, a diversion tunnel from the Eel River to the Russian River, and the Potter Valley hydroelectric power plant. Since 1908, PVP water diversions from the Eel River have generated power, irrigated agricultural land in Potter Valley, and augmented summer flows in the Russian River. PG&E purchased the PVP in September 1929. The quantity of water that can be diverted to the Potter Valley power plant is affected by the releases required to maintain the fishery in the Eel River. Diversion quantity is also affected by an agreement with the U.S. Forest Service to maintain high reservoir levels in Lake Pillsbury until Labor Day of each year for recreational use. The Potter Valley diversion tunnel has a maximum capacity of 350 cfs. From 1922 to 1992, diversions from Lake Pillsbury to the East Fork Russian River watershed averaged 159,000 AFY.

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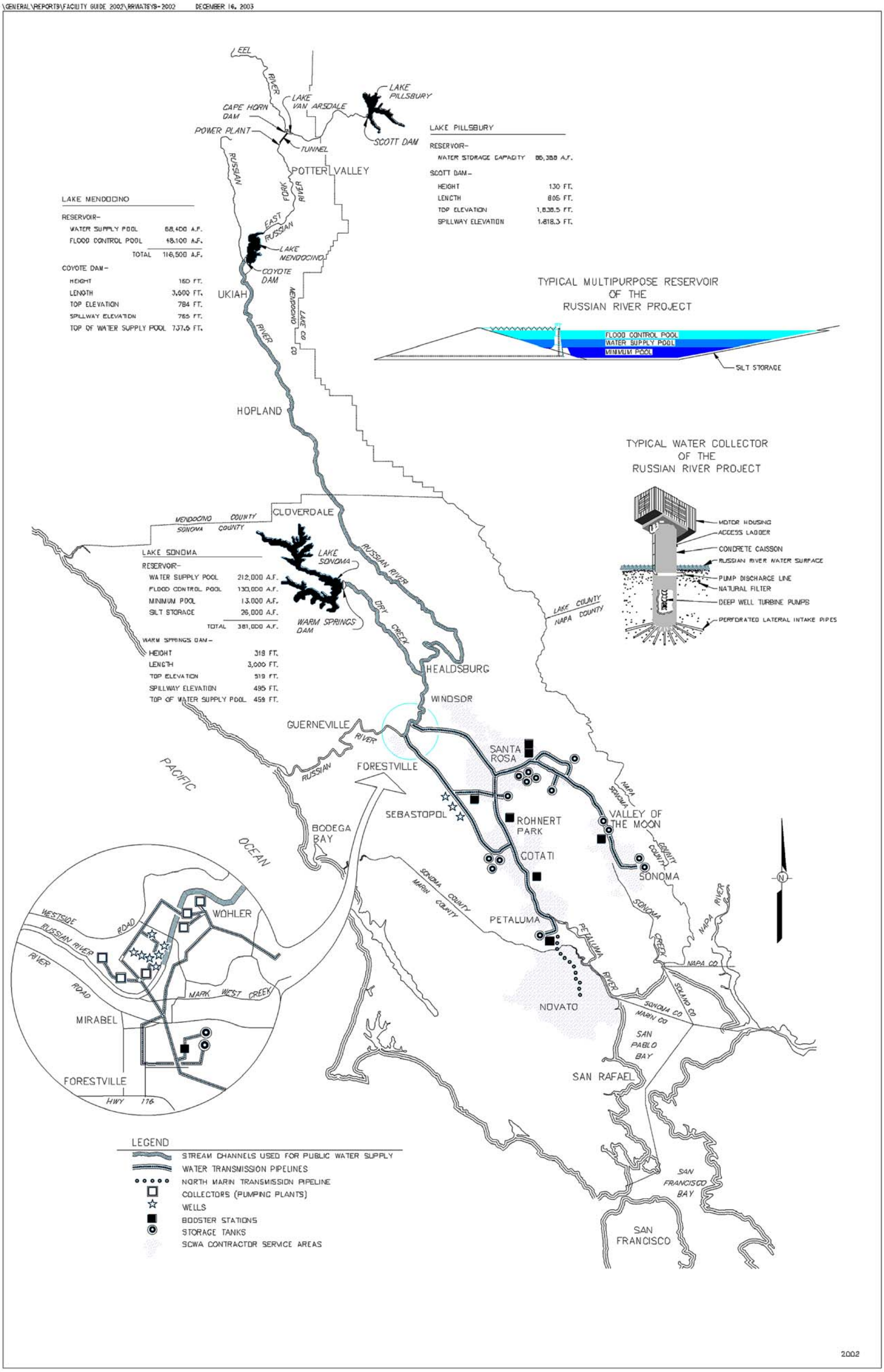

Figure 2-1 The Russian River Water System General Location Map

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Releases from Lake Pillsbury and the PVP are the subject of a separate Section 7 consultation between NOAA Fisheries and FERC (NMFS 2000a). Changes to the release criteria and minimum flow provisions in the 1983 FERC license for the PVP have been proposed and are the subject of an Environmental Impact Statement (EIS) issued in May 2000 by FERC. PG&E has already voluntarily reduced diversions so, if implemented, the proposed FERC license modification analyzed in the EIS would not substantially reduce the quantity of water currently diverted to the Russian River basin via the PVP.

The PVP diversion significantly altered the natural streamflow in the Russian River. Between construction of Scott Dam in 1922 and construction of Coyote Valley Dam in 1959, Eel River water stored in Lake Pillsbury and diverted to the East Fork Russian River helped provide significant base flows throughout the year. Presently, operation of the PVP is not coordinated with the operation of Coyote Valley Dam and is not subject to USACE, SCWA, or MCRRFCD control.

2.1.1.2 Coyote Valley Dam and Lake Mendocino

Lake Mendocino is impounded by Coyote Valley Dam on the East Fork Russian River, approximately 0.8-mile upstream of the confluence with the Russian River. Lake Mendocino is owned and operated by the USACE, San Francisco District, while the USACE Sacramento District's Water Management Division provides complete engineering support for the San Francisco District water management program. Information on the authorizing legislation is provided in Section 1.4.2.

The Coyote Valley Dam project is a multipurpose project providing a high degree of flood protection to areas below Coyote Valley Dam and supplying water for domestic, industrial, and agricultural uses. Releases from Coyote Valley Dam maintain flow in the Russian River during the summer months when the river would otherwise be dry, or nearly dry. Water releases from Coyote Valley Dam are designed to supply an adequate flow of water to the Russian River during the summer months to supply water needs and satisfy instream flow requirements. Winter operations include water storage until the dedicated flood storage space is reached and releases are made for flood control. Coyote Valley Dam and Lake Mendocino facilities and operation are described in detail in Section 3.

2.1.1.3 Warm Springs Dam and Lake Sonoma

Lake Sonoma is impounded by Warm Springs Dam at the confluence of Warm Springs Creek and Dry Creek, approximately 10 miles northwest of the city of Healdsburg. Lake Sonoma became fully operational in 1984. It is a multipurpose facility owned and operated by USACE for the primary purposes of flood control, water conservation, and recreation. Warm Springs Dam and Lake Sonoma facilities and operations are described in detail in Section 3.

2.1.1.4 Inflatable Dam

SCWA's inflatable dam and diversion facilities are located on the Russian River just upstream of the Mirabel area at River Mile (RM) 22. (The "RM" designation refers to the distance from the mouth of the river at the Estuary, upstream to the site referenced.) The inflatable dam is a key component of SCWA's diversion facilities. It consists of a rubber bladder attached to a permanent concrete foundation. The bladder is filled with water and, when fully inflated, the dam is 11 feet tall. The backwater impounded by the dam raises upstream water levels to improve infiltration and facilitate diversion operations. Fish ladders are located on both banks to provide fish passage. Additional details of the inflatable dam facilities and operation are presented in Section 3.3.

2.1.1.5 Fish Barriers

Natural Barriers

Obstacles including shallow water, cascades and falls, log jams, and other natural barriers limit upstream migration of adult salmonids into the upper reaches of tributaries. Locations of some barriers have been documented (CDFG 2002). CDFG reports natural barriers are found in Smith, Freezeout, Matanzas, Thompson, Briggs, Ingalls, Dutcher and Forsythe creeks.

Permanent Dams

Willow County Water Diversion Dam, owned by the Willow County Water District, is located at RM 88 in Ukiah. This permanent dam may affect fish passage into the uppermost reaches of the Russian River, where the best steelhead spawning and rearing habitat of the river is located (CDFG 1991). The dam is constructed of rocks and slabs of old concrete sidewalks, and is used for diverting water for irrigation (Winzler and Kelly 1978).

Seasonal Dams

Seasonal dams are temporary structures placed across the Russian River mainstem and its tributaries to impound water. The main purpose of these dams is to form pools for recreational use, although some also supply water (Winzler and Kelly 1978). These dams range from large structures that span parts of the Russian River mainstem to smaller structures located in the tributaries.

Three major seasonal dams are routinely installed in the mainstem Russian River during the summer recreation season. The major summer dams, starting from the downstream end of the Russian River and moving upstream, are Vacation Beach Dam, Johnson's Beach Dam, and Healdsburg War Memorial Beach Dam. A fourth dam, Del Rio Woods Dam, operated by the Del Rio Woods Recreation and Park District at RM 35, has not been installed since 2001.

Historically, these dams have been installed by the end of May and removed by mid-September so they do not impede the upstream migration of salmon and steelhead spawners. A very small number of Chinook salmon may begin their upstream spawning migration as early as late August. The risk of delay to Chinook salmon spawners, however, is extremely low because most upstream immigration occurs from late October to mid-January (Chase et al. 2001, 2002).

Because the outmigration of salmonid smolts primarily occurs during the winter-spring period and is usually completed by mid-May, the likelihood of outmigration delays due to the erection of the summer dams is low. The small number of Chinook salmon juveniles observed to emigrate between mid-May and June 30 would be delayed at the seasonal dams. However, these delays are likely short as there is generally sufficient flow to allow fish to pass over the tops of the dams.

The major seasonal dams are described below:

- Vacation Beach Dam is located at RM 12. The Russian River Parks and Recreation District operates the dam for recreation. It has a permanent 8-foot-tall concrete base with collapsible steel support beams. Wooden flashboards are installed during the summer to impound water. The dam includes a portable Denil fish ladder to permit fish passage when the flashboards are in place (CDFG 2002).

- Johnson's Beach Dam is located at RM 14 in Guerneville. It is also operated by the Russian River Parks and Recreation District for recreation. It is an 8-foot-tall permanent concrete and steel pier structure, with removable flashboards that are installed around mid-May. The dam also contains a fishway, which is constructed into the face of the dam, and is positioned to function best when water backs up due to the downstream Vacation Beach Dam. Future plans are to change the installation date to after June 15 to ensure there is no effect on the outmigration of salmonids and other fish species such as American shad (CDFG 2002).

- Healdsburg War Memorial Beach Dam is located at RM 32. The Sonoma County Regional Parks Department installs the dam for recreation. It is a 16.5-foot-tall concrete sill structure with removable flashboards and steel support beams. The date of flashboard installation varies from about May 20 to June 26, after most salmonids have finished migrating upstream.

  For Healdsburg Dam, a separate Section 7 consultation between USACE, SCWA, and NOAA Fisheries was conducted in 2000 to address construction and operation of a fish ladder at the dam. The ladder provides upstream passage for American shad and enhances passage conditions for salmonids when the flashboards are down (ENTRIX, Inc. 2000c). SCWA is the principal party responsible for the operation and maintenance of the fish ladder. The new ladder was constructed and began operating in 2002.

Several hundred summer dams are installed annually in tributaries throughout the Russian River (CDFG 2002). Most of these dams are located on private property and are typically used to create pools for recreational activities. The effects of these dams on listed salmonid species may include changes to stream-habitat complexity, diminishing stream water quality, enhancing habitat for salmonid predators, and restricting fish movement (NMFS 2001d). On smaller tributaries, however, Smith (2001, 2002) argues that if food is abundant in the impoundment, summer dams may actually provide improved habitat for steelhead rearing by creating smaller pools in shaded, back-country creeks. These cool pools could provide juveniles with a refuge to grow in before heading out to sea and a safe haven from predators.

Privately-owned summer dams are located primarily on small tributaries that are potential coho salmon and steelhead habitat. These dams can have substantial impacts on rearing and migration of salmon and steelhead, depending on their location, size, and time of deployment. CDFG and NOAA Fisheries have identified these dams as potentially impacting salmonid resources, and have identified specific actions that should be taken to minimize or eliminate these impacts (NMFS 2001d; CDFG 2002).

NOAA Fisheries (NMFS 2001d) prescribes timing of dam installation, conditions surrounding installation and removal, and the various applicable regulatory requirements. Strict enforcement of CDFG Section 1600 permits has recently been intensified in the Russian River as part of the state's efforts to protect and recover coho salmon. While these permits are required for any structure that could alter the structure of the streambed, in 1999 CDFG modified a Section 1600 program to comply with CEQA requirements (CDFG 1999). Currently, all persons who propose to construct a seasonal dam are required to notify the CDFG and to develop an agreement that will protect and/or mitigate any damages to the stream. The CDFG is using the Section 1600 permitting process to ensure that private owners of seasonal dams provide adequate bypass flows for listed salmonids.

NOAA Fisheries (2001d) has identified several effects of summer dams on salmon and steelhead beyond fish passage concerns. For instance, the installation and removal of summer dams near spawning sites can leave developing embryos vulnerable to crushing, cause the silting of redds, and lead to a reduction of DO to developing eggs. The installation of summer dams can also reduce the production of juvenile salmonids by reducing habitat complexity and damaging riparian vegetation. The dam installations can also change the availability of prey food by altering the volume of benthic drift in downstream reaches. Other potential adverse effects associated with summer dams include raising stream temperatures and enhancing the suitability of tributaries for prey species that feed on juvenile salmonids.

Both CDFG and NOAA Fisheries strongly support a shift from seasonal dams to off-stream reservoirs to eliminate much of the fish passage and other dam-associated effects on salmonids and their habitats. The intensified focus of fisheries agencies on the problems associated with seasonal dams and the commitment to intensify enforcement of laws regulating these dams should establish a trend toward eliminating their impacts on salmonid populations throughout the watershed (NMFS 2001d; CDFG 2002).

Road Crossings

Five temporary gravel road crossings on the Russian River and additional crossings on the tributaries provide cross-river access during the dry season. These five crossings are:

- Russian River at Washington School Road in Asti.
- Russian River at Odd Fellows Road near Korbel Champagne Cellars.

- Russian River at Summer Crossing Road in Guernewood Park.
- Russian River at Vacation Beach Avenue at Vacation Beach.
- Dry Creek/Russian River confluence crossing installed by Syar Industries each year.

A semipermanent crossing is installed on Dry Creek near its confluence with the Russian River. In addition to the above crossings, numerous other temporary crossings are installed in the Russian River by gravel mining companies. Two temporary crossings are installed by Shamrock Materials, Inc. near the confluence of Big Sulphur Creek and the Russian River. The exact locations of the gravel mining crossings vary from year to year, depending on the morphology of the Russian River and gravel operation needs. NOAA Fisheries has issued BOs for three gravel operations concerning the construction of summer road crossings and access to gravel mining sites (NMFS 2001a, 2002; NOAA Fisheries 2003c). The crossings have bridges or culverts to allow for streamflow. CDFG biologists report that summer road crossings have little or no effect on fish passage (CDFG 1991), but they may reduce the quality of fish habitat by increasing turbidity and covering aquatic invertebrates (Hopkirk and Northen 1980).

Culverts and Rural Road Crossings

A basin-wide assessment of all Sonoma and Mendocino county-owned culverts was conducted under contract to CDFG in 2001 and 2002 (CDFG 2002). Study protocols were consistent with recent NOAA Fisheries guidelines for salmonid passage at stream crossings (NMFS 2000a). Paved roads run parallel to large tributaries in all reaches of the basin, and numerous small dirt and paved roads in smaller canyons have thousands of culverts or fords at crossings. CDFG will coordinate initial restoration efforts on sites that have the best biological benefit for federal- and state-listed populations of anadromous salmonids (CDFG 2002).

Temperature and Chemical Barriers

Thermal barriers can be caused when low flows, lack of riparian vegetation, impaired hydrologic regimes, or point-source discharges of warm water increase water temperatures above thermal limits of listed fish species. CDFG has identified temperature barriers in long sections of streams within the Big Sulphur Creek watershed, where natural geothermal activity occurs (CDFG 2002). CDFG has also identified temperature barriers in the Maacama Creek watershed (McDonnel Creek subwatershed), where limited riparian vegetation occurs on long stretches of stream. Water temperature within the Russian River is discussed further in Section 2.1.6.1.

Chemical barriers are usually caused by a point-source discharge that makes water quality unsuitable. Wastewater releases may cause migration barriers and/or increased straying (CDFG 2002). CDFG has recommended a number of restorative actions to identify, monitor, and correct potential water quality concerns (CDFG 2002).

2.1.2 LOCAL LAND USES

2.1.2.1 Urban Development

Historical Perspective

Development of the Russian River Valley began in the early 1800s. Cattle and horse ranching were the dominant land uses. As ranching practices increased, much of the lowland area in the watershed was converted from forest to grasslands, with most streams flowing through a narrow corridor of riparian habitat.

The California Gold Rush in 1849 triggered the development of new settlements along the Russian River due to demand for wood and agricultural products from the region. Eventually, land transportation of agricultural products replaced steamboat shipping, resulting in the construction of roads in Sonoma and Mendocino counties. The pace of urban development in Sonoma County accelerated in the late 1800s to support the agricultural industry, particularly wine grape vineyards (Sonoma County 2003a). In 1870, a railroad was established between Petaluma and Santa Rosa. By 1910, Highway 101 was built, becoming a four-lane highway in the 1950s and a major U.S. freeway by 1980 (SCWA 1998a).

Current Practices

Approximately 65 percent of the urban development within Sonoma County is concentrated in Cloverdale, Healdsburg, Santa Rosa, Sebastopol, Rohnert Park, Cotati, Sonoma, Petaluma, and Windsor. All but two of these cities (Sebastopol and Sonoma) are located on Highway 101, the major north-south route through the county. The Sonoma County population in 2000 was 464,800, with 34 percent living in unincorporated areas of the county.

Between 2000 and 2002, the population of Sonoma County grew by 2.1 percent to an estimated size of 468,386 residents by 2002 (USDA Economic Research Service [ERS] 2003). The largest city in the county, Santa Rosa, has added approximately 5,635 residents since 2000, bringing its total population size to an estimated 153,489 residents (California Department of Finance [CDOF] 2003). Sonoma County's projected population growth from 2000 to 2010 is 19.9 percent (Sonoma County Economic Development Board 2003).

Mendocino County is also experiencing population growth, but not at the rate of Sonoma County. The 2000 population was 86,265. Between 2000 and 2002, the population of Mendocino County grew by 1.1 percent to 87,240 residents (USDA ERS 2003). Mendocino County's projected population growth from 2000 to 2010 is approximately 18 percent (CDOF 2001). The county's population is centered in the Ukiah Valley, where the City of Ukiah (the county seat and largest city) is located. Sixty-eight percent of the population live in unincorporated areas of the county, while 18 percent reside in the greater Ukiah area (CDOF 2003).

Residential, industrial, and commercial properties occupy about 6 percent of the land within the Russian River Valley. Communities that border the Russian River mainstem include Ukiah, Hopland, Cloverdale, Asti, Geyserville, Healdsburg, Rio Nido, Guerneville, Monte Rio, Duncans Mills, and Jenner. Communities located on tributaries to the Russian River include Windsor, Larkfield/Wikiup, Santa Rosa, Rohnert Park, Cotati, Sebastopol, Occidental, Camp Meeker, Forestville, and Graton. Several transportation routes connect these communities. These include U.S. Highway 101, State Highways 1, 12, 20, 116, 128, and 175, as well as several county roads and bridges. The Northwestern Pacific Railroad generally parallels the Russian River from Healdsburg north to Calpella. It should be noted that in both Sonoma and Mendocino counties, many residents live outside the Russian River watershed.

Current and future development in the Russian River watershed is based on general plans approved by the incorporated communities, and on general and specific plans developed by Mendocino and Sonoma counties. To date, approximately 90 square miles of the 1,485-square-mile Russian River watershed have been developed for commercial, industrial, and residential needs, with the cities of Ukiah and Santa Rosa showing the fastest growth in light industry and commercial development.

Primary industrial activities in the watershed include production and processing of timber products, wine products, agricultural and animal products, gravel mining, and energy production. Recreation and tourism are also major industries in the watershed, including hiking, camping, canoeing, swimming, fishing, and visiting wineries (Sonoma County 1989; Mendocino County 1981).

Potential Effects on Salmonids

The California Department of Conservation (CDOC) issues maps designed to help local governments evaluate land-use-planning decisions (CDOC 2003). These maps were developed as part of CDOC's Division of Land Resource Protection, which map 44.5 million acres of California's public and private land every 2 years to provide spatial information on land use.

In Sonoma County, urbanization increased at a faster rate between 1998 and 2000 than in the previous 2 years, and a significant amount of land was reclassified from dryland agricultural uses to vineyards and other irrigated crops. Recent maps show that 4,626 net acres in Sonoma County were converted to urban development between 1998 and 2000, compared to only 2,111 acres between 1996 and 1998. There was also a net increase in farmland of 3,469 acres, continuing the trend from 1996 to 1998, in which the county gained 1,260 farmland acres. In general, the increase in urban and irrigated agriculture land has occurred in areas that were historically used for dryland grain and grazing purposes. The CDOC reports that Sonoma County has already committed 1,071 acres to non-agricultural uses, which most likely will be earmarked for development in the future (CDOC 2003).

A study by Harris et al. (2001) on the effects of land policies and management practices on salmon has found that several land-use activities in Sonoma County (and other counties) may pose a risk to anadromous fish. These activities include sediment loading due to improper stream crossings, road failures, bank instability, and other erosion-causing activities associated with development. Additionally, urbanization can degrade water quality through stormwater runoff and removal of riparian habitat. These activities can degrade salmonid spawning and rearing habitat.

2.1.2.2 Gravel Mining

Historical Perspective

Since the mid-1800s, small-scale gravel mining on the Russian River has occurred between Fitch Mountain in Healdsburg and the Wohler Bridge. Gravel mining activity increased in the late 1940s when demand for sand and gravel increased and the USACE began constructing flood control projects. In-channel gravel extraction soon became one of the principal industries for towns located between Healdsburg and Ukiah. Russian River gravels were used in concrete developments and road construction throughout the Russian River Valley and the San Francisco Bay Area (EIP Associates 1994).

In the 1970s, in-channel gravel mining decreased and operations moved to the adjacent terraces along the river. Between 1980 and 1995, approximately 42 million tons (a yearly average of 2.8 million tons) of gravel were removed by instream and terrace mining operations (EIP Associates 1994). In September 1994, the Aggregate Resources Management Plan (ARM) for Sonoma County was revised to address future demands for aggregate resources through 2010. It was anticipated in the ARM Plan that demand would range from 75 million tons to 175 million tons (EIP Associates 1994).

Current Practices

Three extraction methods are used in the Russian River basin: in-channel mining, terrace or pit mining, and quarry mining. In-channel methods remove material directly from stream channels. Gravel is skimmed from bars or excavated directly from active-channel deposits that emerge during low flows. Terrace or pit mining removes gravel from historic or active flood plain deposits. The pits are separated from the active channel by buffer zones of varying width. Some pits are deeper than the adjacent river channel elevation by as much as 44 feet (Steiner 1996). Quarry mining uses sites away from the stream and its floodplain, and uses as much as 20,000 gallons of water per day (gpd) for large operations (EIP Associates 1994).

Entrapment or stranding of fish in depressions associated with gravel mining in the active floodway of the Russian River is a concern. Aggregate and sediment removal operations can leave depressions in mined areas (bars) that can increase the potential for entrapment (NOAA Fisheries 2003b). Of the three extraction methods used in the Russian River, quarry mining has the least direct effect on salmonid habitat.

The ARM Plan, adopted by Sonoma County in 1980 and revised in 1994, established locations, policies, and standards for terrace and instream mining operations (EIP Associates 1994). The objective of the ARM Plan is to manage quarry production on a sustained-yield basis and provide guidelines to reduce bank erosion, maintain flood-flow capacities, protect adjacent land uses, and minimize effects on fisheries, vegetation, and wildlife. The ARM Plan allows instream mining of gravel bars at levels that balance the rate of aggradation and degradation.

In 1998, as part of the 1994 ARM Plan, SCWA assisted the Sonoma County Permit and Resources Management Department in monitoring riparian and aquatic habitat along the Russian River to assess effects of multiyear bar-skimming operations. Monitoring showed a prevalence of undeveloped riparian habitat along stream channels, such as immature forests and vegetative scrub, suggesting there has been an increase in flood scour and a decrease in the size of the active floodplain in recent years. While 52 percent of the existing riparian stands were established before or during 1947, most of the habitat loss on banks and terrace areas has resulted from development of the floodplain (especially since 1987).

One of the predominant issues in the ARM Plan program is to assess the effects of instream mining operations on anadromous fish habitat. To address the effects of mining on salmonids in the Russian River, NOAA Fisheries issued biological opinions (BO) for the mining companies including Syar Industries, Shamrock Materials, Inc., and DeWitt Sand and Gravel (NMFS 2001a, 2002; NOAA Fisheries 2003c, respectively). In their assessment of these mining operations, NOAA Fisheries proposed several conservation measures to minimize the adverse effects of gavel extraction on listed species. NOAA Fisheries also recently issued a BO for gravel mining and habitat enhancement in Austin Creek (NOAA Fisheries 2003d).

The Mendocino County Water Agency is also developing a gravel management plan for the Russian River in Mendocino County to reduce the effects of mining on listed salmonids. Instream mining takes place at four locations in Mendocino County (CDWR 1984). Three of these locations are on the mainstem Russian River below Ukiah, and one instream mining area is located in Redwood Valley on the West Fork Russian River (CDWR 1984).

Potential Effects on Salmonids

NOAA Fisheries (NMFS 2002) has identified several potential effects of gravel mining on Russian River salmonids. These effects include river incision, bank erosion, habitat complexity reduction, and tributary down-cutting (NMFS 2002). The 1994 ARM Plan also found that gravel mining reduces riparian vegetation along stream corridors and increases sediment deposition within streambeds. Finally, EIP Associates (1994) have reported that mining practices can alter flows, especially in high-velocity channels, leading to the removal of spawning gravels. All of these activities can negatively effect salmonids by reducing the amount of quality habitat available for spawning and rearing.

2.1.2.3 Timber Harvest

Historical Perspective

Logging has occurred in the Russian River watershed since the late 1800s. Intensive logging and milling began in 1865, following the construction of a power-driven sawmill in Mirabel Park, and production reached its peak in the mid-1900s (CDFG 2002). After most harvestable redwoods had been removed, loggers switched to Douglas fir during World War II. Since then, timber harvesting in the Russian River watershed has dramatically declined (CDFG 2002).

Current Practices

Since 1975, the California Department of Forestry (CDF) has required logging companies to comply with timber harvest plans (THPs) when harvesting more than 20 acres. Regulations for THPs are set forth in the Federal Forest Practice Act, which is administered by CDF and other state regulatory agencies. These regulations govern harvesting rates, erosion control, watercourse and lake protection, and hazard reduction (CDF 2003).

Currently, less than 5 percent of the timber harvested in California's northwest region comes from the Russian River watershed. Although logging has decreased since the mid-1950s, there are currently many active THPs within the Russian River watershed. While some of the THPs are located near tributaries in the more mountainous regions, most are located in the lower mainstem west of Guerneville, and the upper mainstem near Ukiah (SCWA 1998a).

Potential Effects on Salmonids

The main effect of timber harvesting on fish species in the Russian River is soil erosion (NCRWQCB 2003a). Soil erosion is caused by landslides that result from the destabilization of slopes due to the removal of trees. Timber-related landslides can affect listed salmonids by silting out spawning habitat, raising stream and river temperatures, and destabilizing streambanks (NCRWQCB 2003a).

2.1.2.4 Agriculture

Historical Perspective

By the second half of the 19th century, Mendocino and Sonoma counties had became two of the nation's biggest wine producers. Other crops grown in the region included prunes, apples, cherries, hops, olives, berries, potatoes, asparagus, melons, and other vegetables. The production of eggs, poultry, dairy products, beef, and lamb were also important economic farm commodities (California Farm Bureau Federation 2003). Most land currently in agricultural production has been grazed or cultivated for many years. Substantial areas of undeveloped lands that were not in agricultural production have been converted to vineyards in recent years (CDOC 2003).

Current Practices

Agricultural land in the Russian River watershed is mainly vineyards, and to a lesser extent, orchard crops. Major orchard crops are prunes, pears, and apples, but other crops such as cherries and walnuts are also grown. There is considerable grazing by cattle and sheep in some areas, but far less than in the past. The watershed contains both dry and irrigated pasture, and hay and grains are grown. Irrigation water is generally needed from May through early October. Water is used in the spring for protecting vineyards from frost (USACE 1998b).

In Sonoma County, wine grapes are currently grown on 59,891 acres. Sonoma County's total wine grape production for 2002 was 46,587 acres valued at $376 million (Sonoma County Agricultural Commission [SCAC] 2002). Mendocino County has approximately 15,000 acres of wine-bearing vineyards worth $81 million in 2002 (Mendocino County Agricultural Commission 2002b).

Historically, the demand for North Coast wine grapes far outstripped supply, but that has changed in recent years. Currently, vineyard development has tapered off as a result of a grape surplus in Sonoma and Mendocino counties (M. Vernon, SCAC, pers comm. 2003; G. McCourty, University of California Hopland Research and Extension Center [UC HREC], pers. comm. 2003). This surplus has resulted in lower profits for grape growers (SCAC 2003a).

Potential Effects on Salmonids

In the past few decades, Sonoma County vineyards have expanded to the hillsides, where erosion is a more significant problem than on flat ground. This has lead to additional sedimentation of the Russian River via runoff from hillside vineyards into streams and tributaries (NCRWQCB 2003b).

The NCRWQCB does not have a formal permitting process for vineyards. Recently, Sonoma County adopted a hillside vineyard ordinance to address sedimentation problems associated with vineyard operation. Sonoma County's Agricultural Commission oversees the Vineyard Erosion and Sedimentation Control Ordinance (VESCO), which requires growers to submit erosion control plans for new vineyards with a greater than 10 percent slope. The VESCO also addresses the effect of vineyard operations on riparian areas (SCAC 2003b). This is the first effort by the county to regulate vineyard development.

The 1981 Mendocino County General Plan acknowledges a link between salmonid populations and agricultural practices, but the details of this relationship were not well developed within the plan. The revised General Plan Update, due out in 2006, will evaluate the effects of agricultural activities on fish species in order to reduce negative impacts. Mendocino County recently developed a Draft Grading Ordinance (Mendocino County 2002), that is in the process of being adopted, to regulate grading on public and private lands in unincorporated areas to protect fish habitat.

2.1.2.5 Existing Water Quality Conditions

Water quality sampling programs conducted in the Russian River watershed over the last 20 years indicate substantial improvements in water quality throughout the watershed (NCRWQCB 2002a). Efforts to control both point-source pollution (i.e., discharges from municipal and industrial treatment plants) and nonpoint-source pollution (i.e., urban and agricultural runoff) are largely responsible for improvements in water quality.

Some water quality issues remain in locations near animal (primarily dairy) operations, cultivated agriculture, industrial sites, timber harvesting, and in locations downstream from urbanized areas. These issues include impacts on domestic water supplies and fisheries from stormwater runoff, chemical usage, and wastewater (NCRWQCB 2002a). The NCRWQCB has identified several areas of concern in the tributaries, including sedimentation, riparian vegetation removal, low streamflow, bacteria, channel maintenance practices, and high water temperatures.

Toxic Substance Detection

Toxic substances have rarely been detected in Russian River monitoring programs (NCRWQCB 2002a). Sediment sampling in 1985 to 1986 and again in 1995 detected no pesticides in sediments. Monitoring of heavy metals exhibited no trends, except for higher zinc concentrations downstream from the more urbanized areas. Toxic substance sampling in resident fishes and in transplanted (i.e., caged) freshwater clams as part of the NCRWQCB's Surface Water Ambient Monitoring Program has occasionally detected pesticides and/or heavy metals in tissues. However, the only consistent trend is the presence of mercury in fish from lakes Pillsbury, Mendocino, and Sonoma, detected as part of the Toxic Substances Monitoring Program (NCRWQCB 2002a).

ESA Compliance

The NCRWQCB entered into an agreement with SCWA to review water quality standards and regulations and SCWA activities in the watershed for compliance with the ESA (NCRWQCB 2002a). Water bodies in the Russian River/Bodega watershed management area were assessed in light of existing and proposed standards and permits, and opportunities to improve water quality and salmonid resources were identified (NCRWQCB 2000). The NCRWQCB staff report recommended modifying selected objectives in the Water Quality Control Plan for the North Coast Region (North Coast Basin Plan; NCRWQCB 2000). The recommended changes include adjusting existing standards for DO and temperature to protect critical salmonid lifestages, and adopting new standards for sedimentation, aluminum, and nutrients. The recommendations are currently being finalized by the NCRWQCB.

River Water Quality Monitoring Programs

Data on surface water quality within the Russian River watershed have been collected at over 50 monitoring stations by seven different agencies including the City of Santa Rosa, CDFG, CDWR, Mendocino County Water Agency, NCRWQCB, SCWA, and USGS (Figure 2-2). These stations are located along the mainstem Russian River and in selected

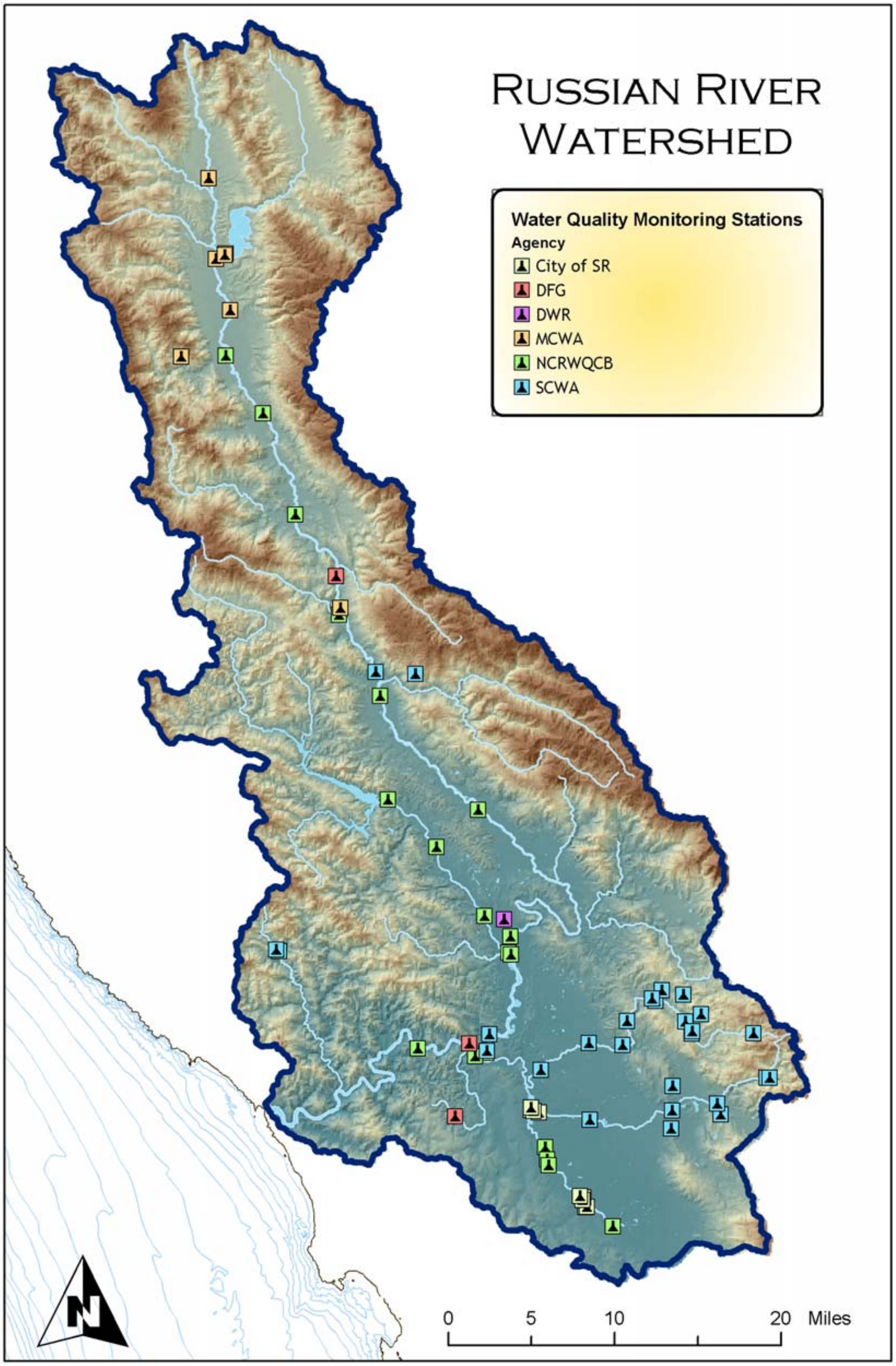

Figure 2-2 Locations of Water Quality Monitoring Stations in the Russian River Watershed. Source: SCWA

tributaries, particularly the Mark West Creek–Laguna de Santa Rosa system. Water quality parameters collected at these stations are variable and primarily include temperature, DO, pH, and specific conductivity. Other water quality parameters occasionally measured include turbidity, chemical oxygen demand, nutrients, metals, organic compounds (including pesticides), chlorophyll, and bacterial abundance. SCWA is currently compiling these data.

Reservoir Water Quality Monitoring Programs

USACE routinely conducts water quality monitoring of Lake Mendocino and Lake Sonoma during April and August of each year (Baum 2003a, 2003b). Samples are collected within the reservoirs and at the inflows and outfalls. Parameters monitored include Secchi disc depths (i.e., a measure of water clarity); water-column profiles for temperature, DO, and pH; phytoplankton; metals; methyl tertiary-butyl ether (MTBE); pesticides; inorganic parameters (i.e., alkalinity, nutrients); and fish-tissue mercury.

Both Lake Mendocino and Lake Sonoma are mesotrophic, which means they have moderate levels of nutrients and phytoplankton productivity (Baum 2003a, 2003b). During the spring, both lakes are thermally stratified. Lake Sonoma continues to exhibit temperature stratification in the summer, whereas Lake Mendocino tends to develop uniformly warmwater temperatures with depth, because releases from the dam are made from the coldwater pool at the bottom of the lake. DO concentrations remain relatively high with depth in Lake Sonoma. However, DO levels decrease with depth in Lake Mendocino (Baum 2003a).

Water quality in both Lake Mendocino and Lake Sonoma is generally good with only occasional exceedances of water quality criteria for the protection of aquatic life, as defined in the California Toxics Rule (CTR) (Baum 2003a, 2003b). Pesticides were not detected in either lake between 1997 and 2002.

In Lake Mendocino, dissolved mercury exceeded the aquatic life criterion in bottom waters in 1999 and 2000, and manganese slightly exceeded the aquatic life criterion in 2001. Mercury may also be elevated in fish tissue (Baum 2003a). MTBE was not detected in Lake Mendocino at concentrations exceeding the detection limit of 2 micrograms per liter (µg/l) (Baum 2003a).

In Lake Sonoma, some metals have exceeded the water quality criteria as defined in the CTR (Baum 2003b). These metals include: dissolved copper in the spring of 1995 and the summer of 1997; dissolved zinc in the summer of 1997; dissolved mercury in bottom waters in 1998, 1999, and 2000 (and possibly elevated in fish tissue based on limited sampling in 2000 and 2001); and MTBE at a concentration of 3 µg/l in the summers of 2000 and 2002 (Baum 2003b).

Total Maximum Daily Load Program

Under Section 303(d) of the federal CWA, states are required to develop lists of impaired waters that still do not meet water quality standards after all known point sources of pollution have been addressed. Section 303(d) requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs) for these waters (EPA 2003a). TMDL lists are to be updated every 2 years.

A TMDL is a quantitative assessment of water quality problems and contributing pollutant sources (EPA 2000). A TMDL includes a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. A TMDL allocates pollutant loadings among all sources and provides a basis for taking actions to achieve water quality standards (EPA 2000). The calculation must include a margin of safety and account for seasonal variation in water quality to ensure that the water body may be used for the purposes that the state has designated.

The Russian River watershed, particularly the tributaries, were included in the Section 303(d) list for impairment due to sedimentation and siltation in December 1997 (NCRWQCB 2001b). TMDLs for these water bodies were given a medium priority with a completion date of 2011. Upon completion of each TMDL, the waste-load allocations will be incorporated into the North Coast Basin Plan through the normal revision process.

The EPA recently approved California's 2002 revision to the Section 303(d) list. This listing added five water body segments in the Russian River to the 1998 list (Table 2-1). Five segments were also placed on the "watch list" for pesticides and metals (NCRWQCB 2001b). Water bodies are added to the watch list when there is either conflicting information on impairment, or there is insufficient data to make a decision. The NCRWQCB is responsible for collecting additional information about the water body segments on the watch list during the Table 2-1 listing cycle. These data will be used to make a determination as to whether to list the water body segment as impaired.

Additions in the 2002 Section 303(d) list include the Laguna de Santa Rosa for DO and nutrients, Santa Rosa Creek for pathogens, and the Russian River for pathogens and temperature. The rationale for these additions is provided in the following paragraphs.

The Laguna de Santa Rosa is seasonally eutrophic (i.e., it has high nutrient levels, high phytoplankton productivity, and low water clarity). The Laguna de Santa Rosa was added to the Section 303(d) list in 1990 due to high levels of ammonia and low DO concentration. A TMDL for ammonia and DO was completed in 1995, and implementation is underway to reduce and/or eliminate nutrient sources necessary to improve water quality as part of a waste reduction strategy. Ammonia goals were met ahead of schedule, but DO continues to be a problem due to nutrient-enriched bottom deposits in the Laguna de Santa Rosa. The Laguna de Santa Rosa was relisted for impairment due to low DO and nutrients in 2002.

Although the quantity of samples is low, microbiological monitoring in Santa Rosa Creek has identified high levels of bacterial indicators (NCRWQCB 2001b). Results from samples collected during June/July 2001 indicated that most samples exceeded one or more of the bacteriological criteria established by the CDHS. Monitoring results from June/July 2001 show high levels of total coliforms, *Escherichia coli (E. coli)*, and *Enterococcus* (City of Santa Rosa 2001, as cited in NCRWQCB 2001b). Total coliform

Table 2-1 Water Quality-Impaired Water Bodies in the Russian River Watershed

Water Bodies	Status	Parameter	Priority	Proposed TMDL Completion Date
Atascadero Creek	Listed	Sedimentation		2011
Green Valley Creek	Listed	Sedimentation		2011
Laguna de Santa Rosa	Listed[1]	DO	Low	
	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
	Listed[1]	Nutrients		
	Watch[1]	Copper, Chromium, Zinc		
	Watch[1]	Diazinon		
Lake Mendocino	Watch[1]	Mercury	Low	
Lake Sonoma	Watch[1]	Mercury	Low	
Russian River	Watch[1]	Diazinon		
Russian River, Austin Creek Hydrologic Service Area (HSA)	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Big Sulfur Creek HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Coyote Valley HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Dry Creek HSA	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Forsythe Creek HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Geyserville HSA	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Guerneville HSA	Listed[1]	Pathogens[2]	Low	
	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Mark West Creek, HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Ukiah HSA	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Santa Rosa Creek	Listed[1]	Pathogens	Low	
	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
	Watch[1]	Copper, Chromium, Zinc		
	Watch[1]	Diazinon		

1 Added on the California 2002 Section 303(d) listing.
2 Listing only covers the Monte Rio area between the confluences of Dutch Bill and Fife creeks, and the Healdsburg Memorial Beach from the Highway 101 crossing to the railroad crossing upstream of the beach.

and *E. coli* levels greater than CDHS-recommended levels were found in 72 percent of the 18 samples analyzed. All of the samples had *Enterococcus* levels exceeding the CDHS-recommended level. There were not enough data collected over a 30-day period to make a determination of water quality objective exceedance for contact recreation, based on the NCRWQCB's North Coast Basin Plan objective for fecal coliform (NCRWQCB 2001b). (Fecal coliforms are indicator organisms for other pathogens.) However, swimming advisories have been issued for Santa Rosa Creek (NCRWQCB 2002a). Healdsburg Memorial Beach and Monte Rio Beach are popular swimming areas on the Lower Russian River. The river in the vicinity of these beaches has regularly exceeded water quality objectives for fecal coliforms (NCRWQCB 2001b). Swimming advisories may be implemented to protect human health in these areas.

Permitted Wastewater Discharges

Approximately 176 facilities are regulated under National Pollutant Discharge Elimination System (NPDES) permits or Waste Discharge Requirements (WDR) by the SWRCB within the Russian River watershed. Most of these facilities are concentrated in the urbanized areas including Santa Rosa and Healdsburg (38 facilities each), Geyserville (17 facilities), Ukiah (16 facilities), and Cloverdale (12 facilities) (SWRCB 2003).

The North Coast Basin Plan adopted by NCRWQCB in 1993 established policy and an implementation schedule for controlling wastewater discharges to the Russian River. Exceptions are made on a case-by-case basis and are defined in the NPDES permit for each discharger. The SWRCB has issued 27 NPDES permits for activities that discharge to surface water. These activities include discharge of domestic and industrial sewage, nonhazardous wastes from dewatering activities (e.g., from CVFF), contaminated groundwater, nonhazardous manufacturing process wastes, and stormwater. Base flows (discharge from facility) and the number of permitted facilities for each of these classifications are provided in Table 2-2.

Table 2-2 Classification of NPDES-Permitted Facilities along the Russian River

Waste Type	Permitted Facilities	Base Flow (mgd)
From dewatering, recreational lake overflow, swimming pool, water ride, or groundwater seepage	6	0.03
Contaminated groundwater	8	0.21
Nonhazardous industrial process waste	3	0.52
Nonhazardous domestic and industrial sewage	9	22.1
Stormwater runoff	1	0.0001

The greatest contribution to flow is from the nine sewage treatment plants that discharge a base flow of 22.1 mgd to the Russian River or its tributaries during a limited portion of the year. These treatment plants are allowed (by NPDES permits) to discharge to surface waters from October 1 through May 14 at a maximum rate, for most treatment plants, of 1 percent of the flow of the receiving water (NCRWQCB 2002a). In addition, the municipal dischargers must meet, or be on a time schedule to meet, advanced waste treatment levels (i.e., tertiary treatment without full nutrient removal) (NCRWQCB 2002a).

The North Coast Basin Plan allows exceptions to the discharge rate provision as specified in individual NPDES permits. The City of Santa Rosa's sewage treatment plant has an exception, as specified in Resolution No. 89-111, that allows discharge rates as high as 5 percent of the flow rate of the Russian River during the discharge period (i.e., October 1 to May 14) when approved by the NCRWQCB's Executive Officer (NCRWQCB 2002a).

Several industrial wastewater discharges are allowed under provisions of NPDES permits that require compliance with applicable water quality standards. Likewise, discharges from the cleanup of contaminated groundwater and discharges from leaky underground petroleum storage tank sites are permitted in low volumes and at nondetectable contaminant levels. The City of Santa Rosa, Sonoma County, and SCWA are co-permittees under an NPDES municipal stormwater permit for stormwater point-source discharges in the Santa Rosa area.

Nonpoint-source discharges from failing septic systems and other sources along the Russian River have not been fully identified (SCWA 1998a).

Stormwater Runoff Sampling

Santa Rosa is the largest municipality within the Russian River watershed that is currently subject to an NPDES stormwater permit (NCRWQCB 2003c). Other smaller municipalities are being required to obtain NPDES permits under Phase II of the stormwater program. The SWRCB has issued a statewide stormwater NPDES permit to the California Department of Transportation to control stormwater discharge from state roadways.

Because SCWA has jurisdiction over flood control channels within the Santa Rosa area, SCWA has entered into an interagency agreement with the City of Santa Rosa and the County of Sonoma for coverage under NPDES Permit Number CA0025054 for stormwater discharges (see Section 4.4.6).

The three agencies—SCWA, City of Santa Rosa, and County of Sonoma—are responsible for managing activities that contribute to stormwater runoff and for conducting monitoring of stormwater during rainfall events. Each agency has different responsibilities in implementing the management and monitoring program (Sonoma, County of, City of Santa Rosa, and Sonoma County Water Agency 2003). The County of Sonoma and SCWA are responsible for performing the chemical monitoring component of the program. This involves collection of water samples in Santa Rosa Creek upstream and downstream of the urban area of Santa Rosa during the "first flush" event (i.e., the first storm that produces 0.1 inch of rainfall and generates runoff at both upstream and downstream sampling locations) and three representative storm events (at least 0.3 inch of rainfall within a 3-hour period) throughout the rainy season. The City of Santa Rosa is responsible for performing biological monitoring during two storm events to assess the biological impact of urban runoff. The biological monitoring includes both benthic invertebrate surveys and bioassays.

During the first permit term (1997 to 2003), samples were analyzed for total suspended solids (TSS); total dissolved solids (TDS); pH; temperature; nitrite and nitrate nitrogen; total Kjeldahl nitrogen (TKN)[1]; total phosphates; dissolved phosphates; fecal coliform; fecal streptococcus; and the priority pollutants (a selection of 126 metals, volatile organic compounds [VOCs], and semivolatile organic compounds [SVOCs]) (Sonoma, County of, City of Santa Rosa, and SCWA 2003). The color, odor, turbidity, and presence of oil sheen and surface scum are described by the sampler on the chain-of-custody form at the time of sample collection.

Many of the chemical constituents for which analysis was conducted were never detected in the 17 rounds of sampling during the first permit term. These constituents, including VOCs and SVOCs, have been eliminated from the future sampling program because there is no reason to suspect that they will be detected in future sampling events (County of Sonoma, City of Santa Rosa, and SCWA 2003).

Additionally, the permittees propose to eliminate metals from future analysis under stormwater sampling (Sonoma, County of, City of Santa Rosa, and SCWA 2003). Of the 17 samples that were analyzed during the first permit term, there was only one detection of any of the metals above the CTR aquatic life criteria (i.e., mercury in October 1998). The detected concentration was just above the detection limit and considered suspect (Sonoma, County of, City of Santa Rosa, and Sonoma County Water Agency 2003). Mercury was not detected in any of the 11 samples collected after this detection.

2.1.3 Hydrology

Surface water hydrology in the Russian River basin strongly reflects the area’s Mediterranean climate: warm, dry summers and cool, wet winters. Greater than 82 percent of the precipitation falls during the months of November through March (Western Regional Climate Center 2003). Snowfall is uncommon except in the highest elevations; most precipitation comes in the form of rain.

Under historical, predevelopment conditions, flows in the mainstem would crest soon after rainstorm peaks. Approximately 80 percent of the annual discharge occurred during winter (Ritter and Brown 1971). Historic maximum winter flows were many times greater in magnitude than winter base flows, and far higher than summer flows, which often dropped to 20 cfs or less.

Facilities owned and operated by PG&E and USACE have altered historical flows in both the mainstem Russian River and Dry Creek. Surface water hydrology changed in terms of timing, frequency, magnitude, and duration of flows. A portion of the winter runoff is now stored behind dams for release during dry months. Average monthly flows decreased

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[1] Total Kjeldahl nitrogen is the sum of the ammonia-nitrogen and organic nitrogen present in the sample. It does not include the inorganic forms of nitrogen (i.e., nitrite and nitrate).

for winter/spring periods, and increased for summer/fall periods. Water imported to the basin substantially increased the amount of water available during the summer season.

From 1908 to 1922, diversions of Eel River water through the PVP to the East Fork Russian River boosted springtime flows, but did not augment late summer flows. Since construction of Scott Dam in 1922, flow in the Russian River downstream of the East Fork has been augmented by water from the Eel River, especially in the summer months. PG&E diverted approximately 159,000 AFY of water, on average, from the Eel River into the East Fork Russian River for power generation at the Potter Valley Project northeast of Ukiah, although less water is currently diverted.

Coyote Valley Dam influences mainstem flow patterns year-round. Dam operations diminish flood peaks, redistribute winter flows, and increase summer flows above Healdsburg by as much as 200 cfs.

Warm Springs Dam substantially modified flow in Dry Creek. Lake Sonoma is operated primarily for flood control, water supply, and recreation. Flood control operations reduce peak flood discharges on Dry Creek and the Russian River below Healdsburg. During stormflow events, Warm Springs Dam is operated to attempt to limit Russian River flows at Guerneville to less than 35,000 cfs.

Water stored behind Warm Springs Dam is released throughout the dry months to support downstream water demands of domestic, municipal, and industrial users. Minimum instream releases under D1610 are also made, in part, to support recreational users. D1610 is described in section 1.4.3 and the flows under D1610 are discussed in Section 3. Summer flows are substantially higher than the pre-project conditions, approximating 100 cfs or more. USGS flow records indicate that prior to the construction of the dam, Dry Creek went dry during the summer.

Augmented summer flows have increased the amount of water that flows to the Estuary, thereby altering it from historical conditions. Before construction of major water projects, mainstem flows often dropped to 25 cfs or less, and at times ceased altogether. Under these conditions, the Estuary likely remained closed to the ocean for weeks or months at a time. Currently, inflows to the Estuary could result in periodic flooding of low-lying properties. As a result, the barrier sandbar is artificially breached, exposing the Estuary to ocean tides (see Sections 1.4.4 and 3.4). Local fisheries experts believe artificial sandbar breaching and high Estuary inflows from the river have altered habitat conditions for listed fish species from historical conditions (CDFG 2002; J. Smith, San Jose State University pers. comm. 2001).

Groundwater hydrology has likely been altered by water development, although these changes are not documented. Bankfull and overbank flows are now less common in reaches influenced by flood control operations at Warm Springs Dam. Furthermore, extraction of groundwater is likely to result in localized effects. Such effects may have changed sections of the Russian River from a gaining reach (groundwater flows from adjacent aquifer adds to riverine flow) into a losing reach (water from river flows into aquifer, reducing river flow). At the same time, increased summer base flows have increased the height of water tables and the extent of saturated soils within mainstem channel banks.

2.1.3.1 Stream Gaging

The USGS collects stage and discharge data at 17 gages along the Russian River and various tributaries, and collects stage data only at an additional 5 gages. Historically, the USGS collected streamflow data at 16 gages besides the 22 currently in operation. USGS has also collected sediment data at eight sites and water quality data at five sites. Table 2-3 shows the average annual discharge at selected locations. Streamflow on the East Fork Russian River near Ukiah represents approximately 50 percent of the average annual flow expected at Hopland, 25 percent of the average annual flow at Healdsburg, and 15 percent of the average annual flow at Guerneville. Average annual discharge on Dry Creek since construction of Warm Springs Dam (period 1983 to 2001) is less than the unregulated (period 1960 to 1983) average annual flow condition. This difference could be due to different weather patterns or changes in irrigation demand between regulated and unregulated periods, and does not necessarily reflect changes due to operation of Warm Springs Dam.

Table 2-3 Average Annual Discharge at Selected Sites in the Russian River Watershed

Site[1]	Drainage Area (square miles)	Period of Record	Avg. Ann. Discharge[2] (cfs)
East Fk. RR near Ukiah	105	1911-1958	375
East Fk. RR near Ukiah	105	1958-2002	569[4]
RR near Hopland	362	1939-1958	733
RR near Hopland	362	1958-2002	659[4]
RR near Healdsburg	793	1939-1958	1,474
RR near Healdsburg	793	1958-2002	837[4]
RR near Guerneville	1,338	1939-1958	2,330
RR near Guerneville	1,338	1958-2002	1,046[4]
Dry Creek near Geyserville	162	1959-1983	342
Dry Creek near Geyserville	162	1983-2002	548[3]

1 Source: USGS gage data at stations near Ukiah, Hopland, Guerneville, and Geyserville.
2 Average annual discharge was calculated by averaging flows at each USGS gaging station.
3 1983 to 2002 represents the period Warm Springs Dam operations affected flow in Dry Creek.
4 1958 to 2002 represents the period Coyote Valley Dam operations affected flow in Russian River.

2.1.3.2 High Flows

The Russian River watershed responds rapidly to variations in rainfall, often resulting in flash floods. On February 17, 1986, peak flows were 26,100 cfs at Hopland, 71,100 cfs at Healdsburg, and 102,000 cfs at Guerneville. Peak flood flow on Dry Creek near Geyserville prior to regulation by Warm Springs Dam was 32,400 cfs on January 31, 1963, and after regulation, the peak flow was 7,600 cfs on January 8, 1995 (USGS gage data), which was almost entirely due to discharge from the Pena Creek tributary downstream of the dam.

During the rainy season (November through May), natural streamflow rather than reservoir releases accounts for most of the flow of the Russian River. Coyote Valley Dam has only a slight effect on winter flood flows at Healdsburg because it controls only 7 percent of the drainage area of the Russian River watershed (USACE 1986a). A study by the USACE in 1986 evaluated the effect of Coyote Valley Dam on the flood of 1964 (a 25-year flood-event). The results indicate that dam operations substantially affect flood peaks at Hopland (29-percent reduction), but have limited effects at Guerneville (7-percent reduction).

The 1.5-year recurrence interval flood (i.e., the flood flow that occurs on average every 1.5 years) is significant because the associated flows are most effective, over the long-term, in forming and maintaining channel morphologic characteristics (Leopold 1994). Typically, the bankfull stage (flows reach the floodplain elevation on most channels) has an approximate recurrence interval of 1.5 years in the annual flood series. Flows greater than the 1.5-year-flood event exceed the channel capacity and overflow the floodplain. The bankfull channel capacities at Ukiah, Hopland, and Guerneville are 7,000 cfs, 8,000 cfs, and 35,000 cfs, respectively (USACE 1986a). Table 2-4 shows the channel capacity and 1.5-year floods at two of these locations.

Table 2-4 Russian River Channel Capacity and 1.5-Year Flood

Location	Channel Capacity	1.5-Year Flow
Hopland	8,000 cfs	12,000 cfs
Guerneville	35,000 cfs	30,000 cfs

The 1.5-year flood at Hopland is approximately 12,000 cfs in the regulated condition and 14,500 cfs in the unregulated condition. By comparison, at Healdsburg the 1.5-year recurrence interval flood is nearly identical in the regulated and unregulated conditions (approximately 25,000 cfs). At Guerneville, the 1.5-year recurrence interval under regulated conditions (as influenced by both Coyote Valley Dam and Warm Springs Dam) is approximately 30,000 cfs, and under unregulated conditions is approximately 37,000 cfs.

In both the regulated and unregulated conditions, the 1.5-year flow at Hopland is greater than the 8,000-cfs channel capacity, and would result in over-bank flows. The 1.5-year regulated flow condition at Guerneville is approximately equivalent to the bankfull channel capacity. Thus, on average, every 2 out of 3 years the flow can be expected to result in one flood that is at least equal to, or greater than, the channel capacity in these reaches.

Warm Springs Dam has significantly reduced flood flows in Dry Creek to less than 25 percent of the pre-dam rates (Swanson 1992). For example, the floods of 1963 and 1986 (5,280 cfs) on Dry Creek were of comparable sizes, but flow regulation by Warm Springs Dam reduced the 1986 peak flood flow by approximately 83 percent (Swanson 1992). The 1.5-year flood was approximately 11,000 cfs before construction of the dam, but has been reduced to approximately 2,500 cfs under regulated conditions. A 5-year recurrence interval flood on Dry Creek was more than 24,000 cfs before regulation by Warm Springs Dam, and is approximately 7,500 cfs today.

2.1.3.3 Low Flows

On April 17, 1986, the SWRCB issued D1610 approving SCWA's appropriative water rights permit application and amending SCWA's existing permits (SWRCB 1986b). The permits issued by the SWRCB under SCWA's applications incorporated, as permit terms, an agreement between SCWA and the CDFG that specified the minimum flows necessary for instream beneficial uses on both Dry Creek and the Russian River (see Section 1.4.3). These permit terms dictate minimum flow in Dry Creek and in the Russian River. Flow regulation under D1610 is described in Section 3.

2.1.4 Historical Channel Dynamics and Sediment Transport

A number of activities have altered channel characteristics in the Russian River and Dry Creek. These activities include streamside and in-river gravel mining, channelization, flood control projects, removal of riparian vegetation, operation of dams and the PVP interbasin water transfers. In general, habitat has become less diverse and less favorable to native fish species (Hopkirk and Northen 1980). The amount of riparian vegetation in the Russian River watershed has greatly decreased since the early 1800s because of agricultural practices, livestock grazing, urban development, flood control, gravel mining, and road construction.

2.1.4.1 East Fork Russian River

There is approximately 0.8 miles of habitat in the East Fork Russian River between Coyote Valley Dam at Lake Mendocino and its confluence with the mainstem Russian River. There is a lack of gravel and cobble recruitment below the dam with some gravel deposition existing near the confluence. This section of river is characterized by channelized, vertical embankments downstream of the dam. There is a lack of instream cover and structure in this reach. Exotic species, including striped bass, have been observed below Coyote Valley Dam (B. Cox, CDFG, pers. comm. 2000). Striped bass have been stocked in Lake Mendocino, but reproduction has not been documented in the Upper Russian River.

2.1.4.2 Upper Reach Russian River

In the Ukiah Valley, the Russian River largely consists of high-velocity run-habitat. Here the river flows in a relatively straight channel and is lined with dense riparian vegetation. Gravel extraction occurs within the river channel and on the floodplain of the Ukiah Valley. Instream gravel mining and trapped sediments in Lake Mendocino on the East Fork caused up to 16 feet of channel bed degradation between the mid-1960s and the mid-1980s at the City of Ukiah, based on historic survey data (Swanson 1992). Based on sedimentation data provided by SCWA, Swanson (1992) estimated that Lake Mendocino had trapped, on average, 21,000 tons of gravel sized sediments annually.

Downstream of the Ukiah Valley, the Russian River enters entrenched reaches through Hopland to Cloverdale and the Sonoma-Mendocino County line before entering the 20-mile-long alluvial Alexander Valley. In the Alexander Valley, the river flows in a wide, shallow, sinuously braided channel that is laterally migrating, causing bank erosion (Swanson 1992). Gravel extraction occurs in-channel, and vineyard development has been taking place on the floodplain. Both degradation and aggradation have been measured at river cross-sections in the valley during the past 2 decades (Swanson 1992).

2.1.4.3 Middle Reach Russian River

The Russian River flows out of the Alexander Valley near the Jimtown Bridge and enters Digger Bend, a sinuous canyon where the channel is confined and bounded by alluvial terraces. Approximately 1 mile east of Healdsburg, the river enters a 10-mile-long alluvial valley (RM 33 to RM 23), known as the "Middle Reach." Dry Creek enters the Russian River approximately 1 mile downstream of Healdsburg, and the Wohler Bridge defines the lower boundary of the reach. In the Middle Reach, the Russian River is a generally straight channel that flows through a 2-mile-wide floodplain. Land use is dominated by vineyards and active or abandoned gravel extraction pits. In the Middle Reach between the Healdsburg Dam and the Wohler Bridge, the channel has the capacity to carry up to the 10-year-flood event. This capacity is due to a lowering of the channel bed by an average of 10 feet (Swanson 1992), and is a result of land-use practices, including grazing and agriculture since the early 1800s and intensive gravel mining since the 1940s. However, gravel mining protocols outlined in the ARM Plan are designed to balance the rate of aggradation and degradation (EIP 1994).

2.1.4.4 Dry Creek

Similar to the Middle Reach of the Russian River, Dry Creek has undergone considerable geomorphic changes, particularly since 1940, when intensive instream gravel extraction was occurring (Swanson 1992). Gravel extraction continued in Dry Creek until 1979. Severe erosion, degradation, and channel-widening occurred on Dry Creek during this period as a result of channel incision of the Russian River by 18 feet at the confluence and the instream gravel extraction on Dry Creek. Aerial photography also indicates vegetation encroachment on many bars and floodplain areas.

2.1.4.5 Lower Reach Russian River

Downstream of the Wohler Bridge, the Russian River flows westerly through a narrow valley bounded by mountains. The channel is relatively straight and deep, with a low floodplain where the town of Guerneville is situated on the north side of the river. Guerneville is subject to frequent flooding, on average once every 5 years. Gravel and sandbars are common along the channel. Below Guerneville, the Russian River flows into its coastal estuary near the confluence with Big Austin and Willow creeks.

2.1.4.6 Laguna de Santa Rosa and Mark West Creek

These tributaries to the Russian River are characterized as low-gradient, and at times, intermittent. Agriculture is common near the banks of Laguna de Santa Rosa and Mark

West Creek. A lack of canopy and instream cover results in high water temperatures. Portions of the banks are channelized for flood control and bank stabilization. Warmwater fish species are common in both streams (R. Benkert, SCWA, pers. comm. 2001).

2.1.4.7 Estuary

The Estuary near Jenner extends approximately 6 to 7 miles from the river's mouth at the Pacific Ocean, upstream to Duncans Mills and Austin Creek in western Sonoma County. Tidal influence has occurred as far as 10 miles upstream to Monte Rio (Russian River Estuary Interagency Task Force [RREITF] 1994). A barrier beach (sandbar) forms naturally across the mouth of the river periodically during the dry season, impounding water and forming a lagoon. The sandbar opens naturally when hydraulic conditions in the Russian River and Pacific Ocean change, or when it is artificially breached. When the sandbar is open, the Estuary is open to tidal mixing. A detailed description of the structure and function of the Estuary is presented in Section 3.4.

2.1.4.8 Other Tributaries

Remaining Russian River tributaries can be grouped into two geographic sets:
1) tributaries to the Estuary, and 2) tributaries to the mainstem above the Estuary. Habitat conditions for the tributaries in each set are discussed in the following sections.

Tributaries to the Estuary Reach

Tributaries to the Estuary include Willow Creek, Freezeout Creek, Dutch Bill Creek, Austin Creek, and their tributaries. These streams have been degraded from logging and grazing activities, but at one time they supported coho salmon and steelhead, as well as other species. Many of these streams maintain a grade-level connection with the mainstem. Habitat conditions in these streams are typified by excessive fine sediment and degraded riparian vegetation. Additionally, the stream morphology has been greatly altered by the deposition of excessive sediment in the lower-gradient reaches closest to the Russian River. Larger systems, such as Austin Creek and its tributaries, generally contain habitat that is in good condition. However, the mainstem of Austin Creek has been used for gravel extraction. In the past, many summer dams were installed every year in the watershed, but have since been removed. Dutch Bill Creek is parallel to the Bohemian Highway and numerous houses and businesses are situated along its length.

Many of these tributaries (Freezeout, Willow, and Austin creeks, and their tributaries) were surveyed for habitat conditions during summer and fall months from 1994 to 1996 (CDFG 1998b). Tributaries were slightly to moderately incised in their middle and upper reaches. Of the 60 to 70 surveyed miles of lower tributaries below Guerneville, 72.4 percent were classified as a Rosgen channel type F or G (Rosgen 1996), which are the likely natural channel types in this watershed. (F-type and G-type channels are low-gradient, meandering channels. G-type channels are steeper than F-channels and have a lower width-to-depth ratio.) This reach originally was likely a wide, shallow, braided channel (Swanson 1992). The overall dominant stream cover was mostly boulders, although root masses and woody debris were found in the upper tributaries. Canopy cover in the surveyed streams tended to be high, and of the 14 tributaries surveyed, nine had over 80 percent canopy cover and four had 50 percent to 80 percent cover. East Austin Creek was the only creek surveyed that had a canopy cover below 50 percent. Instantaneous water temperatures measured during the surveys ranged from a low of 46°F (8°C) to a high of 76°F (24°C). Summer maximum water temperatures averaged in the mid-60s°F. The percentage of pools based upon stream length ranged from 32 percent in Freezeout Creek to 6 percent in Ward and Mission creeks. The average pool-habitat of all surveyed tributaries was 22 percent.

Tributaries to the Mainstem above the Estuary

Santa Rosa Plain Tributaries

The streams of the Santa Rosa plain include Laguna de Santa Rosa, and Atascadero, Mark West, Santa Rosa, and Windsor creeks, and their tributaries. These tributaries drain the area to the south and east of the Russian River between Guerneville and Healdsburg. Most of these tributaries flowing across the Santa Rosa plain are low-gradient streams, and because urbanization has occurred in the area, many are managed as flood control channels. Habitat quality here is poor as a result of levees, armored stream banks, dredging activities, past practices of removing riparian vegetation, and warm summer water temperatures. Tributaries to the Middle Reach of the Russian River between Healdsburg and the Wohler Bridge, where gravel mining occurs, have undergone incision in their lower reaches as the mainstem has incised at some locations.

Streams in the Mark West Creek watershed and their tributaries were surveyed during summer and fall months of 1994 to 1996 (CDFG unpublished data, CDFG 1998b). The surveys found that the Santa Rosa plain tributaries had incised channels. Half of the 48.3 miles surveyed were classified as well-entrenched, low-gradient stream. Instantaneous water temperatures measured during the surveys in the Santa Rosa plain tributaries during July through November ranged from 50°F to 74°F (10.0°C to 23.3°C). Summer maximum water temperatures averaged in the mid-60s°F (approximately 18°C). Canopy cover was relatively high, ranging from 60 percent to 90 percent. Dominant stream cover varied, and included boulders, aquatic vegetation, and root masses. In the streams surveyed, the ratio of pool-habitat to stream length varied from 6 percent to 47 percent. The tributaries of the Santa Rosa plain consisted of an average of 27 percent pool habitats. Habitat quality in upper Santa Rosa Creek and Mark West Creek in the foothills east of Santa Rosa was excellent.

Middle Reach Tributaries

Major tributaries of the Middle Reach of the Russian River include Maacama, Sausal, Big Sulphur, and Dry creeks. Most of the tributaries on the west side of the Middle Reach are minor streams, except for Dry Creek and its tributaries. Dry Creek and its lower tributaries, Felta and Mill creeks, have undergone incision in their lower reaches as a result of mining-induced incision of the Russian River channel and other activities.

Fish population surveys and site-specific habitat assessments were conducted in Sausal and Big Sulphur creeks in the mid-1970s (PG&E 1975). More recently, habitat surveys were conducted on west- and east-side tributaries (Maacama and its tributaries, Felta and Mill creeks, and Palmer Creek and its tributaries) during the summer and fall months of 1996 to 1997 (CDFG 1998b). Habitat in more than 61 percent of the 33.7 miles of tributaries in the Middle Reach showed indications of incision. This incision occurred mainly in the lower reaches of these tributaries. These channels were characterized by multiple channels with very high width-to-depth ratios in the lower reaches of Maacama Creek. This type of channel offers poor quality habitat and may interfere with fish migrating into the system. Instantaneous water temperatures measured during the surveys ranged from 49°F to 80°F (9.4°C to 26.7°C) from June through November. Summer maximum water temperatures averaged in the mid-60s°F. The dominant cover type consisted of boulders and some root masses. The average percentage of pool based on stream length ranged from 5 percent to 55 percent, with an average of 27 percent. Canopy cover for the surveyed streams in the Middle Reach ranged from 48 percent in Maacama Creek to 91 percent in Thornton Creek. Most of these tributaries had canopy covers greater than 50 percent.

Upper Reach Tributaries

Comminsky, Pieta, McNab, Robinson, Feliz, McClure, Ackerman, and Forsythe creeks and the East Fork are the main tributaries of the upper reach of the Russian River, upstream from the Mendocino-Sonoma County line. Most of the East Fork Russian River lies upstream of Coyote Valley Dam. Pieta Creek was sampled for fish populations and habitat characteristics in the mid-1970s (PG&E 1975). More recently, McNab, Robinson, and Ackerman creeks were surveyed for aquatic habitat during the summer to early winter months from 1994 to 1997 (CDFG 1998b). The aquatic habitat survey found that over 60 percent of the channels were incised. Between June and December, instantaneous water temperatures ranged from 51°F to 77°F (10.6°C to 25.0°C). Summer maximum water temperatures during the surveys averaged in the mid-60s°F (approximately 18°C). Dominant substrate for these streams is mainly gravel in the lower reaches, and cobble, boulders, and bedrock in the upper reaches. The dominant cover in Ackerman and Robinson creeks is boulders, and the dominant cover in McNab Creek is root masses. The average pool-habitat ratio based on stream length for the three creeks is 24 percent (ranges from 19 percent to 30 percent).

2.1.5 Habitat Conditions in the Russian River Watershed

Habitat conditions have been assessed within portions of the watershed over the last few decades. The most recent information comes from stream-habitat surveys conducted by CDFG and cooperating agencies such as SCWA. The CDFG Draft Basin Restoration Plan for the Russian River (2002) lists priorities for restoration based on stream inventory data. Streams that can support coho salmon are given first priority in this plan. Much of the watershed is privately owned, and restoration efforts depend on local landowner cooperation.

Gravel and streamflow conditions suitable for salmonid spawning are prevalent in the Russian River mainstem and tributaries (Winzler and Kelly 1978). In the lower and middle mainstem (below Cloverdale) and the lower reaches of tributaries, loss of riparian vegetation and changes in stream morphology have reduced much of the cover. As a result, summer water temperatures exceed 55°F (13°C) by April in some years (Winzler and Kelly 1978), limiting the habitat use in these areas. However, steelhead have been observed utilizing summer habitat as far downstream as Healdsburg (Cook 2003a; Chase et al. 2000, 2001, 2003). Results of a flow-habitat study conducted in the fall of 2001 in the mainstem and in Dry Creek are presented in Appendix F.

The most urbanized portion of the watershed is in Santa Rosa and the Cotati-Rohnert Park areas. These areas contain most of the constructed flood control channels. Natural streams and constructed channels in the Rohnert Park area are generally low-gradient and run through a valley plain from the foothills to the east. Poor summer water quality and low summer flows limit rearing habitat in this region. Stream surveys conducted by the CDFG and by SCWA indicate that approximately 45 to 60 percent of the Laguna de Santa Rosa watershed may be characterized as moderately degraded, and approximately 25 percent as severely degraded (S. White, SCWA, pers. comm. 2002b). However, the Laguna de Santa Rosa has important wetland and flood control functions for this part of the watershed. Santa Rosa Creek drains to the Laguna de Santa Rosa, which, in turn, drains to Mark West Creek. The upper portion of the Mark West Creek watershed, including the Santa Rosa Creek watershed, contains good steelhead rearing and spawning habitat. Much attention has been given in recent years to restoration opportunities in this area.

The western side of the Russian River valley is cooler, subject to coastal fog in the summer, and supports coniferous forest. Some of the best coho salmon spawning and rearing habitat occurs in tributaries in this region. Good quality coho salmon habitat also occurs in the tributaries of the upper portion of the Russian River watershed. In addition, parts of the Mark West and Maacama Creek watersheds contain good coho salmon rearing and spawning habitat.

The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable rearing habitat for steelhead. These areas generally have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing.

Historic spawning distribution of Chinook salmon in the Russian River watershed has not been documented. Suitable habitat exists in the upper mainstem and in low-gradient tributaries, including Dry Creek. A Chinook salmon redd survey was conducted in the mainstem in 2002 and 2003 (see Section 2.2.3).

2.1.5.1 Lake Mendocino

Lake Mendocino contains a non-native, warmwater fishery, and some non-native fish are potential predators of salmon and trout. Non-native predators may escape from the reservoir and may seed downstream habitat when the reservoir spills or releases are made. Nearshore regions in the reservoirs are affected by drawdowns due to water supply releases. When the lake levels are low, CDFG biologists have historically placed dead brush along the nearshore region to provide spawning and rearing habitat in the reservoir.

Lake Mendocino does not provide habitat for native anadromous salmonids because the dam is not passable. “Resident” trout may be present upstream of the lake. These fish may also escape from the reservoir if Lake Mendocino spills.

2.1.5.2 Lake Sonoma

Historically, the basin flooded by Lake Sonoma was heavily forested with a combination of riparian woodland, oak woodland, and redwood-Douglas fir forest. The nearshore region of the reservoir provides the primary habitat for non-native warmwater species for spawning and juvenile rearing. Some of these species are potential predators of salmon and trout and may seed downstream habitat when spills or releases occur.

Lake Sonoma’s water levels currently experience large and rapid fluctuations of 5 feet to 10 feet per month. These fluctuations are the result of runoff collected in the lake, and reservoir releases made for water supply and flood control operations. Because Lake Sonoma has a steeply sloped bottom, the area of shallow water habitat, which is less than 15 feet, decreases as the reservoir level decreases (SCWA 1998a). Because spawning and rearing of most warmwater fish occur near shore, large changes in reservoir levels during spring and summer negatively affect these fish.

2.1.6 WATER QUALITY

Overall water quality in the Russian River Basin was discussed in Section 2.1.3. Water temperature is a key water quality factor that affects salmonid habitat. Activities within the basin also have the potential to affect DO. Sediment loads within the river may affect turbidity, which can affect the feeding ability of salmonids. These important water quality parameters are discussed in greater detail below.

2.1.6.1 Water Temperature

Water temperature is one of the most important factors controlling production and distribution of fish in streams. Water temperature directly affects an organism's ability to survive, grow, and reproduce. Within a species-specific tolerance range, as water temperature increases, an organism’s growth rate and physiological performance (e.g., swimming ability) increases. Water temperatures above this tolerance range result in both a reduction in growth and in overall physiological performance, and an increased susceptibility to disease. Ultimately, excessively high temperatures can result in direct mortality. Factors such as DO levels and food availability affect temperature tolerance of salmonids. However, given adequate food transport and suitable habitat, steelhead may grow well in temperatures that are higher than the optimal temperatures reported in literature, which are generally based on northern stocks (Smith and Li 1983). Optimal and lethal water temperature tolerances vary by species and by lifestage (e.g., salmonid embryos are less tolerant of high temperatures than juveniles).

There are no site-specific temperature tolerance data on the effects of temperature on coho salmon, steelhead, and Chinook salmon in the Russian River. Stream temperatures that restrict salmonids vary with species and apparently by geographical region. Critical temperatures that limit production and survival of coho salmon, steelhead, and Chinook salmon vary widely in the literature.

NCRWQCB is reviewing and revising the water quality objective for temperature in the Russian River basin to protect aquatic life, including listed species in the Russian River. This process includes an in-depth analysis of salmonid water temperature tolerances. NCRWQCB's recommended standards are currently in draft form (NCRWQCB 2000). Water temperature criteria for coho salmon, steelhead, and Chinook salmon are presented in Appendix C, *Evaluation Criteria*.

Little is known about water temperatures in the Russian River before the arrival of non-indigenous people. Natural warming generally occurs in a downstream direction, and mainstem in the lower watershed, as well as lower reaches of some tributaries, may have been warm enough to support a native warmwater fish community. Warm-season water temperatures have likely been reduced in reaches below Lake Mendocino and Lake Sonoma due to coldwater releases from these reservoirs. During summer, water temperatures in the Russian River and Dry Creek generally increase with distance downstream from reservoirs; water temperatures in the lower sections of both streams are generally 10°F to 20°F (6°C to 11°C) warmer than in the upper sections (Winzler and Kelly 1978, Prolysts and Beak Consulting 1984).

Lake Mendocino is usually thermally stratified between March and September. During the months that thermal stratification occurs, water temperatures in the bottom layers of the reservoir are much cooler than in surface layers, because they represent water stored during spring runoff that was insulated from warming by the epilimnion. (The epilimnion is the upper layer of a stratified lake that is warmer and consequently less dense so that it floats over a denser, cooler water layer beneath.) The epilimnion is warmed by the sun and becomes too warm for salmonids during the summer. Releases from Lake Mendocino are made from the bottom layer of the lake (hypolimnion) and are cool as long as thermal gradients are present. However, by the end of the summer when the coldwater pool may be drawn down, water temperatures may be warmer. During June, water temperatures immediately below Lake Mendocino average 55°F (12.8°C). By September, the release water is slightly warmer than the water upstream of the lake (Baum 2003a). In late September or early October, when lake stratification begins to break down, temperatures in releases from the reservoir are in the low 70ºF range. This occurs when Chinook salmon begin entering the system and move upstream.

During late spring and early summer, water temperatures in the uppermost portion of the river, and its tributaries, are optimal for salmonids. During late summer, temperatures become stressful along portions of the mainstem river. Water temperatures generally increase in a downstream direction. Summer temperatures in portions of the Russian River and in many of its tributaries exceed published optimal ranges for salmon and steelhead, particularly during daytime, and may reach lethal levels under certain hydrologic and meteorological conditions (Winzler and Kelly 1978, PG&E 1979).

(However, water temperature thresholds in published literature are based on studies in the Northwest Pacific and may not be appropriate for the Russian River basin.)

Lake Sonoma is thermally stratified during summer months. The epilimnion becomes too warm for salmonid species. A warmwater fishery was established in the reservoir for recreational anglers. The temperature of water released from Lake Sonoma, which is controlled by drawing water from different lake depths, rarely exceeds 60°F (15.6°C). This produces approximately a 4°F decrease in summer temperatures in the Russian River below the Dry Creek confluence (NCRWQCB 1993a, USACE unpublished 1999b). Because release water can be drawn from multiple depths in the lake, and because Lake Sonoma is deeper and has a larger cold water supply, the coldwater layer in the lake is not as likely to be depleted by the end of the summer as it is in Lake Mendocino.

In 1995, SCWA funded development of a water temperature model encompassing Lake Sonoma, Dry Creek below Warm Springs Dam, and the Russian River below Coyote Valley Dam (Resource Management Associates [RMA] 1995). Results of the model under current flow conditions are presented in Section 3.

Summer temperatures in many of the Russian River tributaries exceed the optimum temperature ranges for salmon and steelhead. Temperature recorders placed in Santa Rosa and Mark West creeks indicate that summer temperatures in these streams are suitable for salmonids during the summer, except in the more downstream reaches (SCWA 2003a). Other tributaries, such as Big Sulphur Creek, have summer water temperatures that may be too warm for salmonids in their lower reaches (PG&E 1975). However, many tributaries in the rest of the watershed maintain suitable temperatures for salmonids.

2.1.6.2 Dissolved Oxygen

Growth rates, embryonic development, and fish activity can be limited by a reduction of DO. DO levels vary according to temperature, elevation, the presence of aquatic plants or other aquatic species, and turbulence in the water. DO levels are especially important during egg incubation. Embryos require relatively high intergravel oxygen concentrations for successful development, which must be maintained by oxygenated flow through spawning gravels. Salmonid species require DO levels between 7 to 9 milligrams per liter (mg/l). During the 1977 drought, DO in the lower Russian River dropped as low as 5.4 mg/l, but recorded levels have otherwise remained above 7 mg/l (SCWA 1980).

The hypolimnion (deep-water layer) of Lake Mendocino contains little or no DO during summer, so the water released into the river from deep-water intakes has little DO. However, oxygen is replenished within a few hundred yards of the dam by turbulent mixing (SCWA 1980).

The City of Ukiah operated a liquid oxygen injection ring at the Coyote Valley Dam outlet to maintain DO in release water at or above 7 mg/l, at 7.5 mg/l at least 90 percent of the time, and at a monthly median of 10 mg/l for the year. In 1997, the City of Ukiah discontinued oxygen injection after monitoring showed the system was ineffective and minimum oxygen requirements could be maintained from turbulence in the bypass valves in the piping system. Water released from Lake Sonoma passes over a flip bucket at the outlet works, while water diverted to and through the fish hatchery passes through a series of aeration ponds prior to release into Dry Creek. These measures maintain DO at suitable levels.

2.1.6.3 Turbidity

Turbidity is caused by fine particulate materials, both inorganic and organic, suspended in water. Scattering and reflection of light by these particles reduce penetration of light, resulting in reductions of primary production and visibility. Reduced primary production may affect DO levels and diminish food and cover for fish and aquatic macroinvertebrates (Lloyd et al. 1987). The Russian River and its tributaries are typically more turbid during winter and spring when runoff is highest. Erosion rates have likely been influenced by activities such as timber harvest practices, agricultural development, grazing by livestock, removal of riparian vegetation for flood control, streamside gravel mining, urban development, and road construction.

Turbidity in the mainstem Russian River above Dry Creek increases in response to releases of highly turbid water from Lake Mendocino in the winter- and spring-runoff period (Ritter and Brown 1971).

In some cases, reservoirs trap suspended sediments carried in storm flows, thereby decreasing concentrations of suspended sediments in downstream releases. However, reservoirs produce phytoplankton that elevate turbidities above levels found in in-flowing waters.

Sedimentation is the settling-out of suspended materials from the water. Sedimentation occurs mainly in lakes, reservoirs, and in low-velocity areas of stream channels. Sedimentation can reduce gravel quality and the success of salmon and steelhead spawning, egg incubation, newly emerged salmonids (fry), and insect survival. Female salmon and steelhead, while digging redds (nests) in the gravel, will release fine sediments into the water column where the higher water velocities will carry the sediments downstream. However, when high levels of silt settle on a redd after spawning, eggs can “smother” and die from lack of oxygen. Dead eggs can promote the growth of fungus, which may spread throughout the entire redd.

High winter flows can flush sand and fine sediments from gravel. However, Coyote Valley Dam and Warm Springs Dam have generally reduced the frequency and duration of winter peak flows. Effects of flood control operations are discussed in Section 3.

2.2 BIOLOGICAL RESOURCES

The following sections describe the Russian River fish community and the life-histories and migratory behaviors of coho salmon, steelhead, and Chinook salmon in the Russian River. Information is presented on the distribution and abundance of listed fish species as well as on the genetic variance within and between populations.

To assess the effects of baseline activities and provide data for evaluation in this BA, SCWA instituted a series of studies on the biology of the listed species and on project operations under baseline conditions. Pilot studies were also conducted to assess potential modifications to baseline activities. The data resulting from these studies are presented throughout this document to characterize and evaluate baseline project activities.

2.2.1 Russian River Fish Community

The Russian River and its Estuary support a community of fish species that includes both resident and anadromous species, as well as native and introduced species (Table 2-5). To date, 29 species, including 16 native species, have been collected or observed during SCWA monitoring activities in the lower Russian River during the 1999 and 2000 sampling seasons. Three species not documented during SCWA monitoring activities have been historically reported and recorded in the Russian River: white sturgeon, green sturgeon, and pink salmon. Historically, white and green sturgeon occasionally entered the Russian River, although these species apparently did not spawn or rear their young in the river. Stray pink salmon and chum salmon may occasionally be seen but are not known to reproduce in the Russian River (Hopkirk and Northen 1980; S. White, SCWA, pers. comm. 2003c). Abundant resident species inhabiting the mainstem Russian River include smallmouth bass, Sacramento sucker, hardhead, tuleperch, and California roach (Chase et al. 2000, 2001, 2002, 2003; Cook 2003a).

Streams typically exhibit a gradation in habitat types longitudinally as they flow from their headwaters downstream (Moyle and Nichols 1973). Fish populations change in response to habitat conditions. Two important factors affecting the distribution of fish are water temperature and stream gradient. Changes in the watershed that affect water temperature (primarily alterations to the riparian habitat) influence the longitudinal position where the thermal regime becomes unsuitable for salmonids. Moyle and Nichols (1973; Moyle 1976, 2002) described four freshwater fish zones and a fifth estuarine zone for the Sacramento-San Joaquin river systems. The five zones are the Rainbow Trout Zone, the California Roach Zone, the Squawfish (pikeminnow)-Sucker-Hardhead Zone, the Deep-bodied Fish Zone, and the Estuarine Zone. The borders between fish zones are not distinct, but gradually shift from one zone to another in response to changes in habitat.

Sampling conducted in tributaries to the Russian River (Santa Rosa, Millington, and Mark West creeks) between 1999 and 2001 as part of SCWA's Population Monitoring Pilot Study (Chase et al. 2003) (described in Section 2.2.4) indicates that the fish community in the Russian River basin forms analogous aggregations to those described by Moyle and Nichols (1973; Moyle 1976, 2002). In general, species composition in the larger creeks is dominated by steelhead and sculpin in the upper reaches, with California roach becoming important in the middle reaches (Chase et al. 2003). In lowland tributary channels, California roach, sculpin, and Sacramento sucker are the dominant species (Chase et al. 2003). Moyle (1976) describes the Rainbow Trout Zone as headwater streams with relatively high gradients, and cold (seldom greater than 21°C), well-oxygenated water. Fish communities in this zone are dominated by rainbow trout, although sculpin are often found in the lower portions of the zone. Upper Mark West and

Table 2-5 Fishes of the Russian River Watershed

Family	Scientific Name	Common Name	Status
Acipenseridae	*Acipenser transmontanus*	white sturgeon	Native
	Acipenser medirostris	green sturgeon	Native
Catostomidae	*Catostomus occidentalis*	Sacramento sucker[1]	Native
Centrarchidae	*Lepomis macrochirus*	bluegill[1]	Introduced
	Lepomis cyanellus	green sunfish[1]	Introduced
	Lepomis microlophus	redear sunfish	Introduced
	Pomoxis annularis	white crappie[1]	Introduced
	Micropterus dolomuieu	smallmouth bass[1]	Introduced
	Micropterus salmoides	largemouth bass[1]	Introduced
Clupeidae	*Alosa sapidissima*	American shad[1]	Introduced
Cottidae	*Cottus asper*	prickly sculpin[1]	Native
	Cottus gulosus	riffle sculpin[1]	Native
Cyprinidae	*Lavinia symmetricus*	California roach[1]	Native
	Mylopharodon conocephalus	hardhead[1]	Native
	Orthodon microlepidotus	California blackfish[1]	Native
	Lavinia exilicauda	hitch[1]	Native
	Ptychocheilus grandis	pikeminnow[1]	Native
	Pimephales promelas	fathead minnow[1]	Introduced
	Notemigonus crysoleucas	golden shiner[1]	Introduced
	Cyprinus carpio	carp[1]	Introduced
Embiotocidae	*Hysterocarpus traski*	Russian River tuleperch[1]	Native
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback[1]	Native
Ictaluridae	*Ameiurus catus*	white catfish[1]	Introduced
	Ameiurus spp.	bullhead[1]	Introduced
	Ictalurus punctatus	channel catfish	Introduced
Percichthyidae	*Morone saxitalis*	striped bass[1]	Introduced
Petromyzontidae	*Lampetra tridentata*	Pacific lamprey[1]	Native
	Lampetra richardsoni	western brook lamprey[2]	Native
		river lamprey[3]	
Poecillidae	*Gambusia affinis*	mosquitofish[1]	Introduced
Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon[1]	Native
	Oncorhynchus keta	chum salmon[1]	Native/Stray
	Oncorhynchus mykiss	steelhead[1]	Native
	Oncorhynchus kisutch	coho salmon[1]	Native
	Oncorhynchus gorbuscha	pink salmon	Stray

[1] Observed during SCWA monitoring activities in the Russian River during the 1999 and 2003 sampling seasons.
[2] Observed during SCWA monitoring activities in the Russian River during 2002 sampling season.
[3] Caught by Merritt Smith Consulting.
Sources: Cook 2003a; Cook and Manning 2002; Chase et al. 2001; Chase et al. 2000; Chase et al. 2003; Hopkirk and Northen 1980.

Santa Rosa creeks are analogous to the Rainbow Trout Zone. The California Roach Zone is typified by warm, intermittent streams. California roach is the dominant species in the middle section of Mark West Creek and below Highway 12 on Santa Rosa Creek.

The Squawfish (pikeminnow)-Sucker-Hardhead Zone is found in the mainstem Russian River (Chase et al. 2001), but riffles in the upper reach have been observed to be dominated by rearing steelhead with few, if any, pikeminnow, suckers, or hardhead (SCWA 2002, unpublished data). However, pikeminnow may move into the riffles at night to feed.

Abundant species in the Estuary include threespine stickleback, topsmelt, prickly sculpin, starry flounder, and staghorn sculpin (SCWA 2001b; J. Roth, pers. comm., as cited in Resource Management International, Inc. [RMI] 1997). Other species observed during monitoring activities (including otter trawl and beach seine sampling) at the Estuary are listed in Table 2-6 (Merritt Smith Consulting [MSC] 1997a, 1997b, 1998, 2000; SCWA 2001b).

2.2.2 LIFE-HISTORIES AND MIGRATORY BEHAVIORS OF COHO SALMON, STEELHEAD, AND CHINOOK SALMON

Coho salmon, steelhead, and Chinook salmon are anadromous species (although steelhead may also exhibit a life-history type that spends its entire lifecycle in fresh water). These species migrate upstream from the ocean as adults and spawn in gravel substrate. Their eggs incubate for a short period, depending on water temperature, and generally hatch in the winter and spring. Juveniles spend varying amounts of time rearing in the streams and then migrate out to the ocean.

2.2.2.1 Coho Salmon

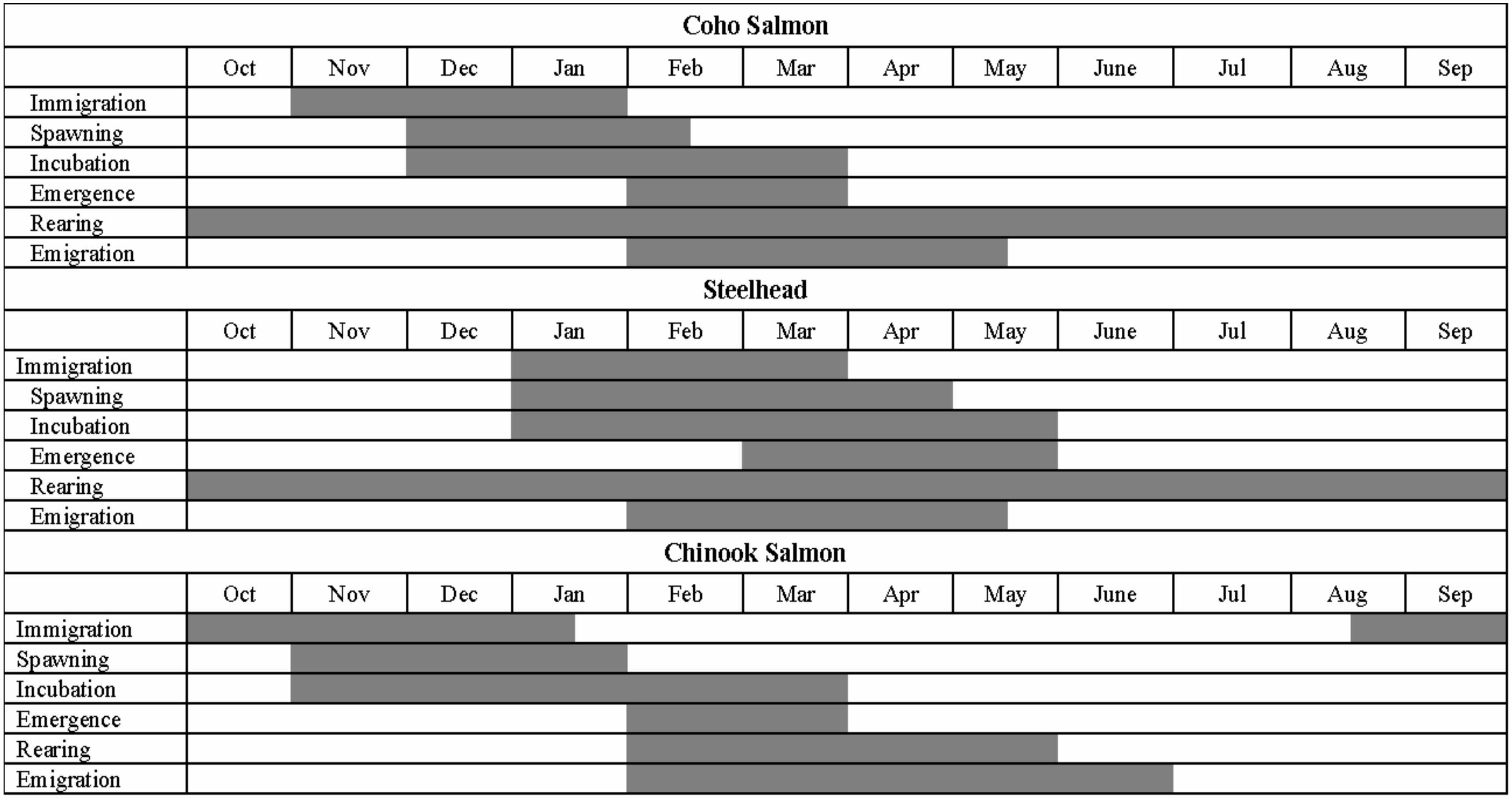
The coho salmon life-history is quite rigid, with a relatively fixed 3-year lifecycle. The best available information suggests that life-history stages occur during times shown in Figure 2-3 (Chase et al. 2000 to 2003; Hopkirk and Northen 1980; Moyle 1976; Moyle et al. 1989; Steiner Environmental Consulting 1996). Most coho salmon enter the Russian River in November and December and spawn in December and January. Spawning and rearing occur in tributaries to the lower Russian River. The most upstream tributaries with coho salmon populations included Forsythe, Mariposa, Rocky, Fisher, and Corral creeks, but coho salmon have not been found in these streams in recent years (see Section 2.2.3). The mainstem below Cloverdale serves primarily as a passage corridor between the ocean and the tributary habitat.

After hatching, young coho salmon spend approximately 1 year in fresh water before they become smolts (undergo a physiological change for adaptation to seawater) and migrate to the ocean. Freshwater habitat requirements for coho salmon rearing include adequate cover, food supply, and suitable water temperatures. Primary habitat for coho salmon includes pools with extensive cover. Outmigration takes place in late winter and spring. Coho salmon live in the ocean for a year and a half, return as 3-year-olds to spawn, and then die. The factors most limiting to juvenile coho salmon production are not completely

Table 2-6 Fish Species Observed in the Russian River Estuary, 1992 to 2000

Family	Scientific Name	Common Name	Status
Atherinidae	*Atherinops affinis*	Topsmelt	Native
Bothidae	*Citharichthys sordidus*	Pacific sanddab	Native
	Citharichthys stigmaeus	speckled sanddab	Native
Catostomidae	*Catostomus occidentalis*	Sacramento sucker	Native
Centrarchidae	*Lepomis cyanellus*	green sunfish	Introduced
	Lepomis macrochirus	Bluegill	Introduced
	Micropterus dolomieui	Smallmouth bass	Introduced
Clupeidae	*Clupea harengus pallasii*	Pacific herring	Native
Cottidae	*Artedius lateralis*	Smoothhead sculpin	Native
	Artedius notospilotus	bonyhead sculpin	Native
	Cottus asper	prickly sculpin	Native
	Enophrys bison	buffalo sculpin	Native
	Enophrys taurina	bull sculpin	Native
	Leptocottus armatus	staghorn sculpin	Native
	Scorpaenichthys marmoratus	Cabezon	Native
	Sebastes paucispinis	Bocaccio	Native
	Sebastes melanops	black rockfish	Native
Cyprinidae	*Cyprinus carpio*	carp	Introduced
	Lavinia symmetricus navarroensis	Navarro roach	Native
	Mylopharodon conocephalus	hardhead	Native
	Ptychocheilus grandis	Sacramento pikeminnow	Native
Embiotocidae	*Cymatogaster aggregata*	shiner surfperch	Native
	Hyperprosopon anale	spotfin surfperch	Native
	Hyperprosopon argenteum	walleye surfperch	Native
	Hyperprosopon ellipticum	silver surfperch	Native
	Hysterocarpus traskii	Russian River tuleperch	Native
Engraulididae	*Engraulis mordax*	northern anchovy	Native
Gadidae	*Gadus macrocephalus*	Pacific tomcod	Native
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback	Native
	Aulorhynchus flavidus	tube-snout	Native
Gobiesocidae	*Gobiesox maendricus*	northern clingfish	Native
Gobiidae	*Clevelandia ios*	arrow goby	Native
Hexagrammidae	*Hexagrammos decagrammus*	kelp greenling	Native
	Ophiodon elongatus	lingcod	Native
Osmeridae	*Hypomesus pretiosus*	surf smelt	Native
	Spirinchus thaleichthys	longfin smelt	Native
Pleuronectidae	*Isopsetta ischyra*	hybrid sole	Native
	Parophrys vetulus	English sole	Native
	Platichthys stellatus	starry flounder	Native
	Psettichthys melanostictus	sand sole	Native
Pholididae	*Pholis ornata*	saddleback gunnel	Native
	Apodichthys flavidus	penpoint gunnel	Native
Poecillidae	*Gambusia affinis*	Mosquitofish	Introduced
Salmonidae	*Oncorhynchus mykiss*	Steelhead	Native
	Oncorhynchus tshawytscha	Chinook salmon	Native
Sciaenidae	*Genyonemus lineatus*	white croaker	Native
Syngnathidae	*Syngnathus griseolineatus*	bay pipefish	Native

Source: SCWA 2001b.



References: Hopkirk and Northen (1980); Moyle (1976); Moyle et al. (1989); Steiner Environmental Consulting (1996); Chase et al. (2000 to 2003).

Figure 2-3 Phenology of Coho Salmon, Steelhead, and Chinook Salmon

understood, but may include high water temperatures, poor summer and winter habitat quality, and predation.

2.2.2.2 Steelhead

Unlike coho salmon, steelhead do not have a fixed 3-year lifecycle. Steelhead spend 1 to 2 years in the ocean before returning to spawn for the first time, and may return to the ocean and spawn again in a later year. Adult steelhead generally begin returning to the Russian River with the first heavy rains of the season in November or December, and continue to migrate upstream into March or April. Adult steelhead have been observed in the Russian River during all months (S. White, SCWA, pers. comm. 1999). However, the peak migration period tends to be January through March (Figure 2-3).

Flow conditions are suitable for upstream migration in most of the Russian River and larger tributaries during the majority of the spawning period in most years. Sandbars blocking the river mouth in some years may delay entry into the river. However, when the sandbar is closed, the flow may be too low and water temperature too high to provide suitable conditions for migrating adults farther up the river (CDFG 1991).

Most steelhead spawning takes place from January through April, depending on the time of freshwater entry (Figure 2-3). Steelhead spawn and rear in tributaries from Jenner Creek near the mouth to upper basin streams, including Forsythe, Mariposa, Rocky, Fisher, and Corral creeks. Low numbers of wild and hatchery juvenile steelhead were observed in the Russian River near Wohler Pool during the first 3 years of sampling for SCWA's inflatable dam/Wohler Pool Fish Sampling Program, but more substantial numbers were documented in 2002. Snorkel surveys in sites throughout the mainstem in the summer and fall of 2002 documented more substantial steelhead numbers, mostly above Cloverdale but also as far downstream as Healdsburg (Cook 2003b).

Distribution of steelhead was correlated with water temperatures (Cook 2003b). The highest temperatures occurred in the Alexander Valley and Healdsburg reaches (25ºC and 24ºC, respectively). Although maximum temperatures were as high as 22ºC and 22.5ºC in the Ukiah and Canyon reaches, respectively, steelhead observed in these reaches during diver surveys appeared healthy and vigorous. Based on these observations, it appears that steelhead may rear in suitable habitat within the mainstem Russian River through the summer.

After hatching, steelhead usually spend 2 years in fresh water, but can spend 1 to 4 years. Fry and juvenile steelhead are extremely adaptable in their habitat selection.

Requirements for steelhead rearing include adequate cover, food supply, and suitable water temperatures. The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable habitat; generally, these areas have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing. The lower reaches of some tributaries provide less cover; these streams are often wide and shallow, have little riparian vegetation, and water temperatures are often too warm to support steelhead. In the summer, these areas can completely dry up. Available cover has been reduced in much of the mainstem and in many tributaries due to loss of riparian vegetation and changes in stream morphology.

Emigration usually occurs between February and June, depending on flow and water temperatures. Steelhead smolts emigrate through the Wohler Pool at an average size of approximately 175 millimeter (mm) fork length (FL) (range 83 mm to 250 mm) (Chase et al. 2001). Sufficient flow is required to cue smolt downstream migration. Excessively high water temperatures in late spring may inhibit smoltification in late migrants.

2.2.2.3 Chinook Salmon

Adult Chinook salmon begin returning to the Russian River as early as late August, but most upstream migration occurs in October and November (Chase et al. 2001, 2002).

Chinook salmon may continue to enter the river through December and spawn into January (Figure 2-3). Adult Chinook salmon migrate upstream to their spawning habitat, located primarily in the mainstem Russian River above Asti and in selected tributaries such as Dry Creek.

Unlike coho salmon and steelhead, the young Chinook salmon begin their outmigration soon after emerging from the gravel. Freshwater residence in coastal California stocks, including outmigration, usually ranges from 2 to 4 months. Juvenile Chinook salmon in the Russian River emigrate as fingerlings from late February through June. Chinook salmon in the Russian River emigrate through the Wohler Pool at approximately 80 mm FL by mid April (the start of the peak emigration period), with a range over the season of 34 to 140 mm (Chase et al. 2001, 2002).

Ocean residence can be from 1 to 7 years, but most Chinook salmon return to the Russian River as 2- to 4-year-old adults. Like coho salmon, Chinook salmon die soon after spawning.

2.2.3 Species Range and Abundance

Data describing the historic range of coho salmon, steelhead, and Chinook salmon in the Russian River basin are limited. However, CDFG has compiled and reviewed salmonid presence data collected between 1920 and 2000 for streams in the Russian River watershed. Figure 2-4 is a CDFG map of the Russian River basin, showing salmonid distribution by species based on presence data from 1920 to 2000.

For salmonid populations in California coast ESUs, the present depressed condition appears to be the result of several long-standing, human-induced factors (e.g., habitat degradation, timber harvest, water diversions, and artificial propagation) that exacerbate the adverse effects of natural environmental variability from such factors as drought and poor ocean conditions. NOAA Fisheries has prepared several documents that address the factors that have led to the decline of coho salmon, steelhead, and Chinook salmon (NMFS 1995, 1996a, 1996b, 1998a, 1998b). These reports generally conclude that all of the factors identified in Section 4(a)(1) of the ESA have played a role in the decline of coho salmon, steelhead, and Chinook salmon. The destruction and modification of habitat, overutilization for recreational and/or commercial purposes, and natural and human-made factors are identified in these reports as the primary reasons for the decline of these west coast salmonids.

SCWA monitored the entire Chinook salmon run for the first time in 2000 at the Mirabel inflatable dam, and estimated a run of 1,500 Chinook salmon in 2000 and at least that many in

2001 (Chase et al. 2001, 2002). A total of 5,466 Chinook salmon adults were observed in 2002 (Chase et al. 2003).

There are no recent population estimates for coho salmon or steelhead in the Russian River. Population estimates for steelhead (1,750 to 7,000 adults) have been widely cited from McEwan and Jackson (1996), who attribute these estimates to CDFG. However, conversations between CDFG biologist Bill Cox and SCWA staff indicate that these estimates were based on professional judgment, and not on specific sampling data, studies, or research (S. White, SCWA, pers. comm. 1996).

Data describing the historic abundance of coho salmon, steelhead, and Chinook salmon in the Russian River watershed are scarce. Investigations into historic estimates of abundance reveal that there have not been any accurate fish counts or population estimates conducted for coho salmon, steelhead, or Chinook salmon in the Russian River basin. Early estimates were based largely on inconsistent angler catch data and newspaper accounts. For example, estimates of steelhead population numbers cited as CDFG 1965 in NOAA Fisheries' *Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California* (NMFS 1996a), were based on estimates by Hinton (1963), who extrapolated on estimates from Evans (1959). Hinton's methodology is described in Prolysts and Beak (1984) as follows:

"Hinton (1963) expanded estimates of adult steelhead runs in three tributaries (East Branch Russian River, Dry Creek, and Santa Rosa Creek) to the total Russian River on the basis of proportionate stream mileage and drainage area. He estimated the annual Russian River run at 50,000 fish. The above estimate of 2,000 fish at the base of the Coyote Dam [2,000 was estimated by Evans (1959) based on the rescue of 379 fish at the base of the dam] was used for the East Branch. Estimates for Dry Creek and Santa Rosa Creek were based on brief field visits made in connection with proposed developments."

The history of the derivation of steelhead population data, described above, exemplifies the lack of reliable, high-quality population data for salmonids in the Russian River basin. Table 2-7 summarizes the presence of listed salmonid species in recent years.

2.2.3.1 Coho Salmon

Coho salmon are generally considered to be less widespread and less abundant than Chinook salmon or steelhead in the Russian River basin. Coho salmon spawn and rear in tributaries to the Russian River. Emigrating smolts and adults migrating upstream use the mainstem Russian River primarily for migration to and from spawning and nursery areas in the tributaries. There are no data indicating that coho salmon spawn or rear in the mainstem.

Historic distribution of coho salmon included numerous tributaries in the lower and upper Russian River as far north as Corral Creek. Presence-absence data for coho salmon presented in the status review update (NMFS 1998b) and CDFG surveys (unpublished data) identify streams within the entire Russian River basin for which coho salmon presence has been noted since 1989 (Table 2-8). Data have been prioritized to indicate streams for which: 1) the most recent survey recorded coho salmon presence; 2) the most recent survey recorded coho salmon absence but which had an equal or greater number of surveys noting coho salmon presence; 3) the most recent and the majority of surveys recorded coho salmon absence.

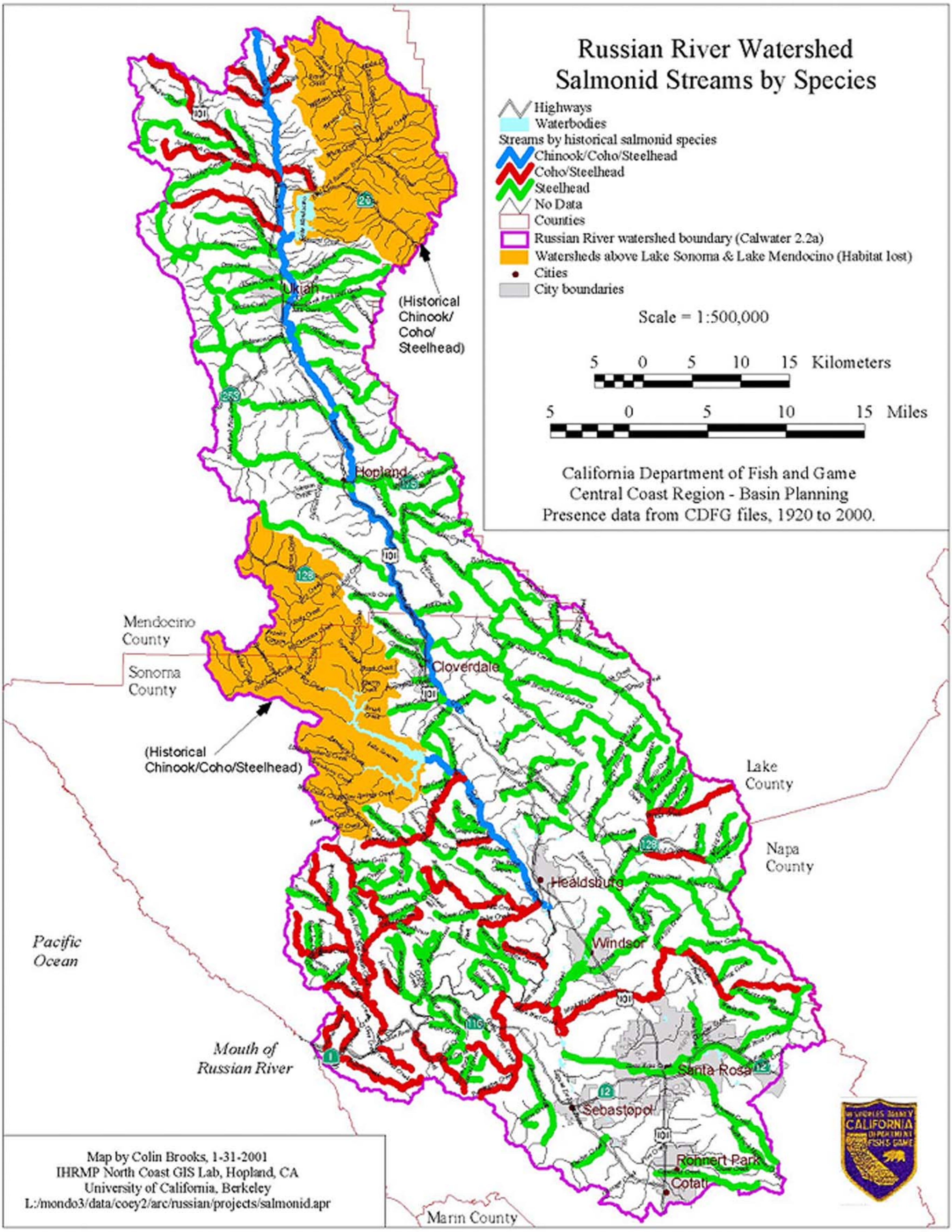


Figure 2-4 CDFG's Map of Salmonid Distribution in the Russian River Basin

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Table 2-7 Presence of Listed Salmonid Species in Russian River and Tributaries

Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present	Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present
Alder (Mendo Co.)		X		Duncan	X	X	
Angel		X		Dutch Bill		X	
Baker's		X		Dutcher		X	
Bear		X		Duvoul		X	
Bear Canyon		X		East Austin		X	
Bearpen		X		East Fork Russian River		X	X
Bidwell		X		Eldridge		X	
Big Austin		X		Fall		X	
Big Sulphur		X	X	Felta	X	X	
Black Rock		X		Feliz			X
Blue Gum		X		Fisher	X	X	
Blue Jay		X		Forsythe	X	X	X
Blue Line		X		Franz		X	
Briggs		X		Freezeout	X	X	
Chapman Branch		X		Gibson		X	
Conshea		X		Gill		X	
Coon		X		Gill South Fork		X	
Corral	X	X		Gilliam		X	
Crane		X		Gird		X	
Crocker		X		Grape		X	
Devil		X		Gray		X	
Doolin		X		Green Valley	X	X	
Dry		X	X	Griffen (Un-named)		X	

Table 2-7 Presence of Listed Salmonid Species in Russian River and Tributaries (Continued)

Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present	Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present
Grub		X		McClure		X	
Hale		X		McDonnell		X	
Harrison		X		McDowell		X	
Hobson		X		Mercer (Un-named)		X	
Howell		X		Mill	X	X	
Hulbert		X		North Fork Mill		X	
Ingalls		X		Millington		X	
Jack Smith		X		Miller		X	
Jenner Gulch		X		Mission		X	
Johnson		X		Morrison		X	
Jonive		X		Olema		X	
Kidd		X		Orrs		X	
Laguna de Santa Rosa	X			Palmer		X	
Lancel		X		Parsons		X	
Lancel North Fork		X		Pechaco		X	
Little Briggs		X		Pena		X	
Little Sulphur		X		Peterson		X	
Lovers Gulch		X		Pole Mountain		X	
Maacama	X	X		Porter		X	
Maacama (Upper)		X		Purrington	X	X	
Mariposa	X	X		Redwood	X	X	
Mark West	X	X		Robinson		X	

Table 2-7 Presence of Listed Salmonid Species in Russian River and Tributaries (Continued)

Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present	Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present
Martin		X		Rocky	X	X	
Mainstream Russian River	X	X		Squaw		X	
S.B. Robinson		X		Sturgeon		X	
Salt (Un-named)		X		Sulphur		X	
Salt Hollow		X		Thompson		X	
North Fork Salt Hollow		X		Turtle (Un-named tributary)		X	
Santa Rosa	X	X		Tyrone Gulch		X	
Sausal		X		Walker		X	
Seward		X		Wallace		X	
Sexton		X		Ward	X	X	
Sheephouse	X	X		Willow	X	X	
Sheephouse East Fork		X		Wine	X	X	
Sheephouse SW Tributary		X		York		X	
Smith		X					

1 Presence data were modified from NMFS 2001 with CDFG unpublished data.
2 Unpublished California Department of Fish and Game 2001 data from the electrofishing database for the Russian River watershed (CDFG in preparation).
3 Merritt Smith Consulting salmonid juvenile density monitoring in Sonoma County streams, synthesis of a 9-year study (1993 to 2001).

Table 2-8 Coho Salmon Presence/Absence for Russian River Tributaries since 1990

Stream Name	Present Years[1]	Years None Detected	Survey Priority[2]
Willow Creek	1990, 95	1991, 92, 93, 94, 96, 98, 2000, 01, 02	2
Sheephouse Creek	1996, 1995	1998, 2001	2
Freezeout Creek	1995	1994, 96, 2000, 01, 02	2
Ward Creek	1996	2001, 02	2
Dutch Bill Creek	2002	2001	1
Green Valley Creek	1993, 94, 95, 96, 97, 99, 00, 01, 02	1998	1
Purrington Creek	1994	2001	1
Mark West Creek	1993, 94, 95, 2001	1996, 97, 99, 2002	1
Laguna de Santa Rosa	1994		3
Santa Rosa Creek	1993, 94	1995, 2001	2
Mill Creek	1995	1996, 2001, 02	1
Wine Creek	1998	2001, 02	3
Unnamed (Turtle) [3]	1996	2001, 02	3
Maacama Creek	1993, 94, 95	1996, 97, 99	3
Redwood Creek	1993, 94, 2001	1995, 96, 97, 99, 2002	1

1 Presence/absence data were modified from NMFS 2001b with CDFG unpublished data.
2 First-priority streams are those streams for which the last survey recorded the presence of coho salmon at some life-history stage. Second-priority streams are those streams for which historical presence is noted, but more recent surveys did not record presence. Third-priority streams are those streams for which multiple recent surveys have not recorded the presence of coho salmon.
3 Presence noted in an unnamed tributary.

There have been no recent efforts to quantify coho salmon populations in the Russian River, and a reliable estimate of coho salmon abundance within the basin has never been developed. Criteria used by NOAA Fisheries (NMFS 1998b) to evaluate population trends for the coho salmon status review update required a minimum of 6 years of abundance data for which sample sites and survey methods were consistent over all years. There are no streams within the Russian River basin that have 6 years of abundance data. Though limited in sample size, coho salmon data collected since 1989 indicate very small numbers of coho salmon exist within relatively isolated pockets of the Russian River. In 2001 and 2002, 32 and 28, respectively, of the historic coho salmon streams within the Russian River were sampled for juvenile coho salmon. Coho salmon were found in only three of these steams in 2001 and two streams in 2002 (CDFG unpublished data 2001a and 2002b). Genetic studies indicate populations in the Russian River basin are highly inbred (Hedgecock et al. 2003).

No coho salmon have been observed during survey efforts conducted between 1999 and 2001 on Mark West, Santa Rosa, and Millington creeks for SCWA's Russian River Basin Steelhead and Coho Salmon Monitoring Program (Pilot Study). However, CDFG reports coho salmon present in Mark West Creek in 2001 (CDFG unpublished data 2001). Green Valley Creek appears to be the only current stronghold for coho salmon. The DCFH on Dry Creek at Warm Springs Dam produced and released an average of approximately 70,000 Age 1+ coho salmon each year, from 1980 to 1998. However, no coho salmon have been produced at the hatchery since 1998

2.2.3.2 Steelhead

Historical data show that steelhead are widespread in the Russian River watershed, occupying all of the major tributaries and most of the smaller ones (Table 2-7 and Figure 2-4).

Most spawning and rearing habitat for steelhead is likely to occur in high-gradient habitats present in tributaries. During snorkel surveys conducted by SCWA in 2002, rearing steelhead were observed in the upper mainstem, mostly between Hopland and Cloverdale, but also as far south as Healdsburg (Cook 2003b). Observation of large numbers of young-of-the-year (YOY) steelhead during recent monitoring by SCWA at the Mirabel inflatable dam and Wohler Pool indicate that some spawning and juvenile rearing may occur in the lower and middle mainstem before smolt outmigration (see Section 2.2.4).

There is general agreement that the steelhead population has declined in the last 30 years (CDFG 1984, 1991), but limited quantitative data are available to support this assumption. SCWA, CDFG, and NOAA Fisheries are currently developing programs to monitor trends in salmonid populations for the basin, and recent, short-term population data are available for two streams: Santa Rosa and Mark West creeks (Cook and Manning 2002).

There has been substantial planting of hatchery-reared steelhead within the basin, which may have affected the genetic constitution of the remaining natural population. Almost all steelhead planted prior to 1980 were from out-of-basin stocks (Steiner 1996). Since 1982, stocking of hatchery-reared steelhead has been limited to progeny of fish returning to the DCFH and the CVFF.

2.2.3.3 Chinook Salmon

Historic data show Chinook salmon presence in the mainstem Russian River, the East Fork Russian River, and Dry Creek (Figure 2-4). Chinook salmon currently spawn in the mainstem upstream of Asti and in larger tributaries, including Dry Creek (Steiner 1996; B. Coey, CDFG, pers. comm. 2000a). Chinook salmon tissue samples were collected in 2000 by SCWA, CDFG, and NOAA Fisheries from the mainstem, Forsythe, Feliz, and Dry creeks. There were anecdotal reports of Chinook salmon in the Big Sulphur system.

It is uncertain whether or not naturally-spawning Chinook salmon were historically present in the Russian River (NMFS 1999c). There is little information pertaining to Chinook salmon populations prior to the completion of the PVP project in 1922. Snyder (1908) described Chinook salmon in the Russian River. Steiner (1996) reviewed historical reports for records of Chinook salmon. Cannery records from before 1890 suggest that most of the salmon harvested were too small (less than 20 pounds) to be Chinook salmon. Several reports and correspondences (Shapovalov 1946, 1947, 1955; Murphy 1945, 1947; Pintler and Johnson 1958; Fry 1979, cited in Steiner 1996) suggest there were few, if any, Chinook salmon in the river. However, recent SCWA trapping data indicate that fish size may be a poor indicator of species. Of the few (16) Chinook salmon trapped, only 10 percent were larger than 20 pounds (S. White, SCWA, pers. comm. 2003a). Other reports and communications indicate that Chinook salmon spawned in the upper portions of the river (Lee and Baker 1975), and that Chinook salmon were harvested by local tribes in Coyote Valley prior to the construction of Coyote Valley Dam (W. Jones, CDFG, pers. comm., cited in Steiner 1996).

Chinook salmon population estimates beginning in the 1960s suggest that in the past, documented returns might have been associated with periods of sustained hatchery stocking. CDFG estimates Chinook salmon escapement in 1966 was 1,000. USACE in 1982 reported an estimated escapement of only 500, despite heavy planting in Dry Creek during the 1980s. Adult returns to DCFH fell short of total escapement goals, although it is unknown what portion of the return was harvested through sport and commercial fishing. The largest adult Chinook salmon return to DCFH was 212 fish, excluding grilse (12 percent of the goal in 1988 to 1989).

Smolt emigration studies and adult counts conducted by SCWA at the Mirabel inflatable dam since 1999 provide the most reliable estimates of Chinook salmon abundance within the basin (Chase et al. 2000, 2001, 2002). The 2002 mark/recapture study estimated over 200,000 Chinook salmon smolts passed the dam from March 27 through June 8 (Chase et al. 2003). These data show that although Chinook salmon have not been stocked in recent years, natural reproduction has occurred. Furthermore, video monitoring of the fish ladders documented substantial numbers of adult Chinook salmon. The smolt emigration studies and monitoring of adult passage are described in Section 2.2.4. Distribution of Chinook salmon redds observed during a 2002 survey of the Russian River is presented in Figure 2-5. Redd surveys in 2003 found several Chinook redds in the mainstem Russian River and in Dry Creek (Cook 2004).

2.2.4 Summary of Current Salmonid Distribution and Abundance Studies

SCWA has initiated several studies in recent years to address the need for additional data describing salmonid population trends, distribution, habitat use, and abundance in the Russian River basin. Studies currently in progress include a population monitoring program designed to detect trends in salmonid populations in the basin, and a fish-sampling program designed to assess potential effects to salmonids from SCWA's inflatable dam. Studies were conducted under a Section 10(a)(1)(a) permit, issued to SCWA by NOAA Fisheries. Information from these studies specifically relevant to the status of salmonid species in the Russian River is briefly summarized in the following sections. Additional information from these studies is described where relevant in other sections of this BA.

2.2.4.1 SCWA's Population Monitoring Pilot Study – Electrofishing Surveys

SCWA has initiated a population-monitoring program designed to detect trends in salmonid populations and to identify possible fisheries management and enhancement opportunities in the watershed. The program is referred to as the Russian River Basin Steelhead and Coho Salmon Monitoring Program (Pilot Study). It began in fall 1999 with a pilot study to collect detailed information on the distribution, habitat use, and abundance of juvenile coho salmon and steelhead in streams of the Russian River basin (Cook and Manning 2002). Streams sampled include Santa Rosa, Millington, and Mark West creeks (tributaries of the Russian River). Santa Rosa and Millington creeks were sampled in 1999; all three creeks were sampled in 2000; and Santa Rosa and Millington creeks were sampled in 2001. In addition, surveys were conducted on Sheephouse Creek in 2000, and Green Valley Creek in 2001. Study methods and results are described in Cook and Manning (2002) and are summarized briefly below.

Summary of Study Methods

Fish sampling was conducted along the three study streams within selected reaches. Stream reaches were distinguished by channel type as described by Rosgen (1996).

The three channel types sampled in the study included:

B2 Channel: Streams with moderate entrenchment, moderate gradient, and aquatic habitat dominated by riffles and occasional pools.

C4 Channel: Low-gradient, meandering streams dominated by riffle and pool habitats.

F4 Channel: Low-gradient, entrenched streams with a broad bed and dominated by riffle and pool habitats.

Each channel type was divided into subreaches and habitat units for fish sampling purposes. Within each stream reach, habitat data were sorted into three general habitat types: riffle, flatwater, and pool. All study reaches included the three habitat types, except Santa Rosa Creek F4 Channel, which had only flatwater and pool habitat types.

Electrofishing was used to sample fish and consisted of a stratified random sampling method. Fish scales from a sample of captured fish were collected for age analysis. Habitat data were collected at habitat units, including maximum water depth, length, and average width.

Summary of Results

No coho salmon were observed during the electrofishing surveys, while steelhead were captured in all three study streams and in most sample units. A total of 31,795 fish were captured during the 3-year study and 6,835, or 21.5 percent, were steelhead. In general, steelhead was the predominant species in the B2 Channel headwater reaches of the three study streams.

<u>Santa Rosa Creek</u>

Where steelhead were present, the predominant age class was YOY with a few older fish present. (Population age distributions would normally have greater numbers of the youngest fish.) In 1999, the age-class composition of steelhead greater than 1 year old was 0 percent in the F4 Channel, 8 percent in the C4 Channel, and 17 percent in the B2 Channel. Similar age-class trends occurred in 2000 and 2001. These data indicate that the C4 and B2 channels provide the primary rearing and year-round habitat for steelhead, and the F4 Channel is primarily used for migration.

The population trend from 1999 to 2001 in Santa Rosa Creek varied by habitat type, but in general included a peak in 2000 with relatively lower numbers observed in 1999 and 2001. This trend was likely affected by annual rainfall.

<u>Millington Creek</u>

Millington Creek is a small headwater tributary of Santa Rosa Creek located in Mt. Hood Regional Park. Steelhead ranged from 78 to 89 percent of the total catch. Species composition along this reach consisted of native steelhead and sculpin. The population trend from 1999 to 2001 in Millington Creek included a peak in 2000 with lower numbers observed in 1999 and 2001.

<u>Mark West Creek</u>

The Mark West Creek study area included an F4 Channel reach above the confluence with Santa Rosa Creek, followed by a lower B2 Channel and C4 Channel located in the foothills, and an upper B2 Channel in the mountainous headwaters. Species composition along this reach varied from several native and non-native warmwater species in the F4 Channel lowlands with less than 1 percent steelhead, to a composition of 100 percent steelhead in the upper B2 Channel headwaters. YOY and a few fish older than 1 year were present. Because surveys were conducted during a single year, no population trends could be evaluated.

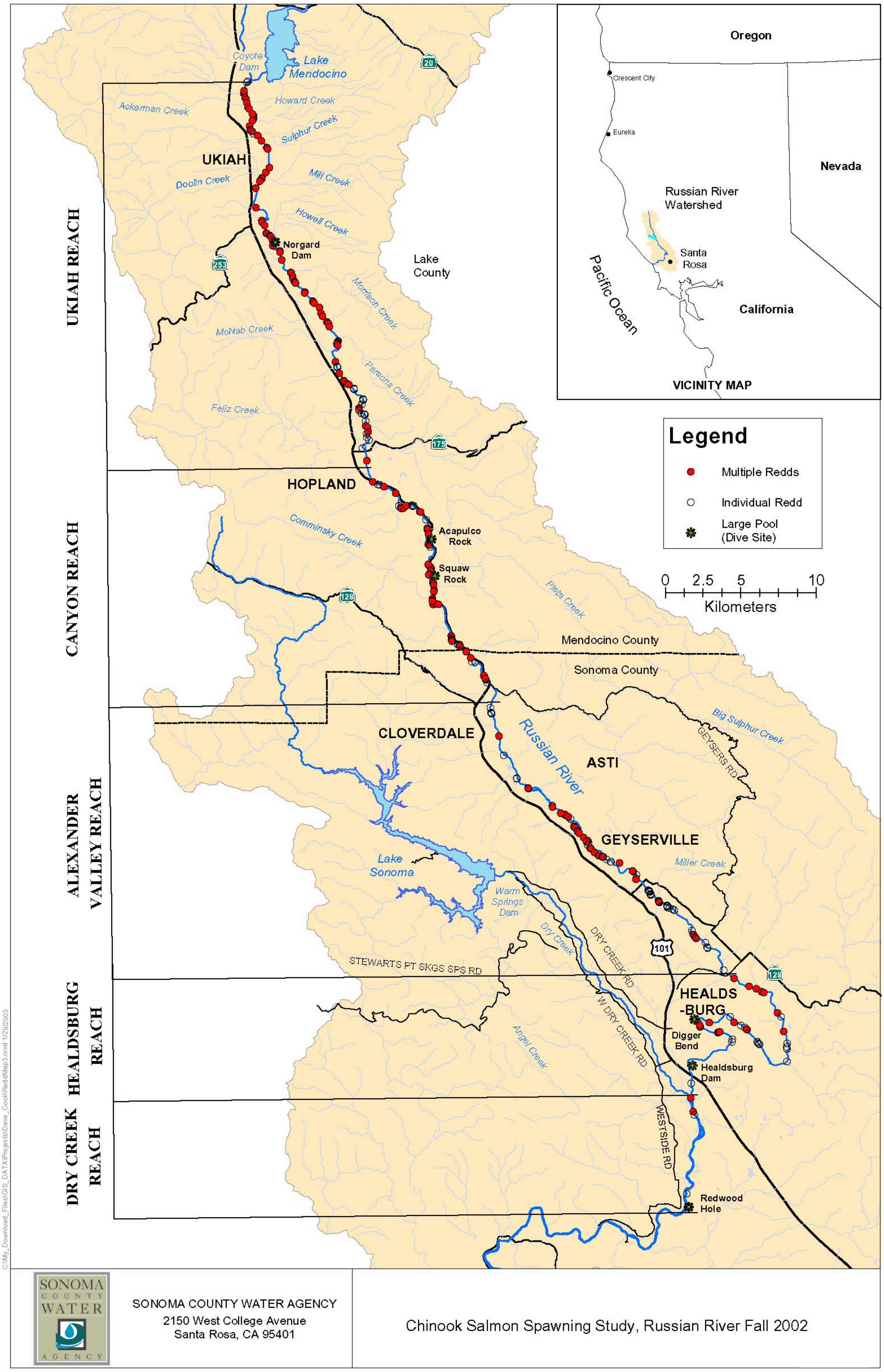

Figure 2-5 Chinook Salmon Spawning Study, Russian River

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2.2.4.2 SCWA's Population Monitoring Pilot Study – Snorkeling Surveys

In addition to the electrofishing surveys described above, snorkeling surveys are being conducted as part of the Russian River Basin Steelhead and Coho Salmon Monitoring Program. Presence-absence surveys were conducted on Sheephouse Creek in 2000, and Green Valley Creek in 2001. These creeks were selected for the study based on recent reports of coho salmon occurrences. Snorkeling survey methods and results are described in Cook and Manning (2002) and are summarized briefly below. The mainstem Russian River from Healdsburg to Ukiah was surveyed in 2002 (Cook 2003b). Snorkeling survey methods in the mainstem Russian River were different; .5-kilometer (km) reaches were surveyed by teams of three, one on each bank and one in the center, and a certain number of sites per reach of river were surveyed.

Snorkel surveys were conducted in pools with a maximum depth greater than 40 centimeters (cm) and underwater visibility at least 200 cm. On Green Valley Creek, single-pass observations were made in each pool to establish presence/absence of coho salmon or steelhead, and the number of each species observed was estimated and recorded. SCWA staff employed a two-phase survey design on Sheephouse Creek to estimate fish abundance. The two-phase survey design was developed by David Hankin from Humboldt State University Department of Fisheries and is described in Cook and Manning (2002).

Snorkeling surveys were conducted on an approximate 3.3-km-reach of Sheephouse Creek between September 27 and October 5, 2000. Surveys were conducted in 122 of 157 total pools in the study reach (78 percent). A total of 450 YOY and 195 steelhead greater than 1 year (Age 1+) were observed during the surveys. Other species observed included sculpin and suckers. No coho salmon were observed in Sheephouse Creek. The estimated population of YOY steelhead in Sheephouse Creek was 680 ± 60, based on the snorkel-survey results. It was not possible to estimate total population for the Age 1+ class of steelhead.

Snorkeling surveys were conducted on an approximate 2.5 km-reach of Green Valley Creek between August 22 and September 6, 2001. Snorkel surveys were conducted after CDFG collected 212 coho salmon from the sampling reaches for a hatchery captive broodstock program. Surveys were conducted in 43 of 98 total pools in the study reach (44 percent). A total of 230 YOY steelhead, 78 Age 1+ steelhead, and 422 YOY coho salmon were observed during the surveys. Other species observed included roach, stickleback, green sunfish, and sculpin.

Cook (2003b) examined the extent of potential rearing habitat in the mainstem of the Russian River. The study area extended 106 km along the river from Ukiah to Healdsburg and included four reaches, the Ukiah, Canyon, Alexander Valley, and Healdsburg reaches. Dive surveys were conducted in summer and fall 2002 to count fish at randomly selected river segments, and habitat characteristics were recorded. Steelhead distribution and relative abundance are presented in Figure 2-6.

Steelhead were observed in all four study reaches, but their distribution and numbers varied substantially. The distribution of steelhead was related to water temperatures. Maximum water temperatures of study reaches generally increased in a downstream direction, and data collected during dive surveys were comparable to permanent temperature stations located in the study reaches. Steelhead in the Ukiah and Canyon reaches (with survey site maximum temperatures of 22ºC and 22.5ºC, respectively) appeared "healthy and vigorous." The highest temperatures occurred in the Alexander Valley and Healdsburg reaches (25ºC and 24ºC, respectively), which may be a factor in the lower fish counts. Habitat also appeared to be a factor. Steelhead were almost exclusively found in riffle and cascade habitats, but were seldom seen in flatwater and deep pool habitats. Food transport in faster water may help steelhead to grow in relatively high water temperatures. Riffle and cascade habitats were most frequently found in the Canyon reach. Species and habitat composition are summarized in Figure 2-7.

2.2.4.3 SCWA's Inflatable Dam/Wohler Pool Fish Sampling Program

SCWA's inflatable dam/Wohler Pool Fish Sampling Program is a 5-year study designed to assess effects to salmonids associated with operation of SCWA's inflatable dam facility. The dam impounds approximately 5.1 km (3.2 miles) of river, creating a long pool (the "Wohler Pool").

A pilot study was conducted in 1999 to assist in developing the study plan for the Mirabel inflatable dam/Wohler Pool Fish Sampling Program. The sampling program was initiated in 2000. Results of fish sampling activities conducted during the pilot study (1999) and the first three sampling seasons (2000 to 2002) are summarized below.

The sampling program has several components:

- Water-temperature monitoring in Wohler Pool to evaluate the thermal regime in the pool, to determine if the impoundment results in an increase in the rate at which water warms as it passes through the Wohler Pool, and to determine if the pool becomes thermally stratified during the summer months. Characterization of the fish community in the Wohler Pool to determine species composition and to assess the relative abundance of predatory fish (on salmonids) above the inflatable dam.
- Evaluation of hatchery steelhead smolt emigration through the Wohler area using radio telemetry to determine if operation of the inflatable dam affects smolt emigration.
- Timing and relative abundance evaluation, using rotary screw traps, of Chinook salmon and steelhead smolt emigration past the inflatable dam.

Monitoring adult upstream migration to verify that anadromous fish are able to successfully ascend the existing fish ladders located at the inflatable dam. Monitoring adult upstream migration and the evaluation of the timing and relative abundance of

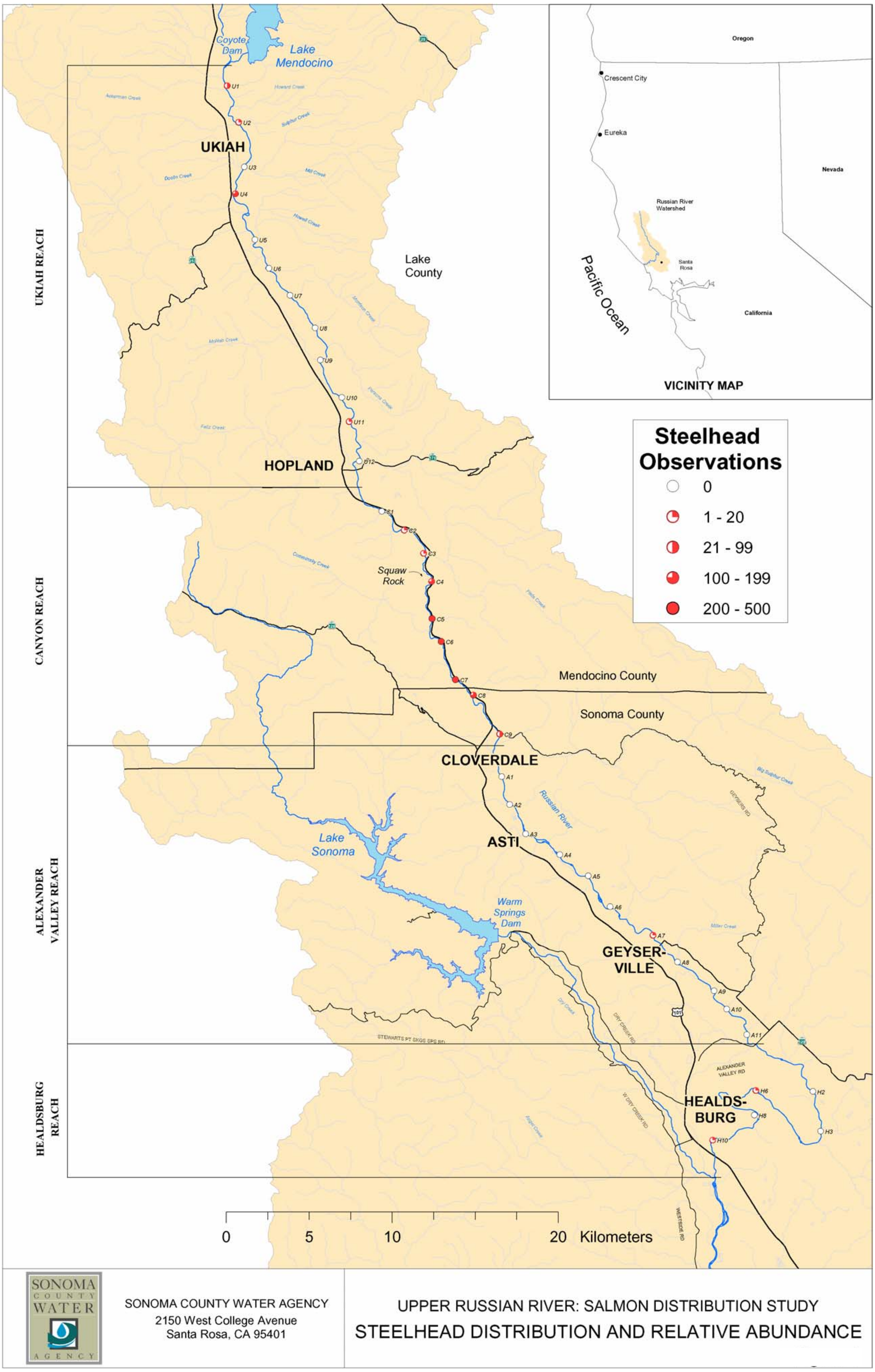

Figure 2-6 Steelhead Distribution and Relative Abundance in 2002 (Cook 2003)

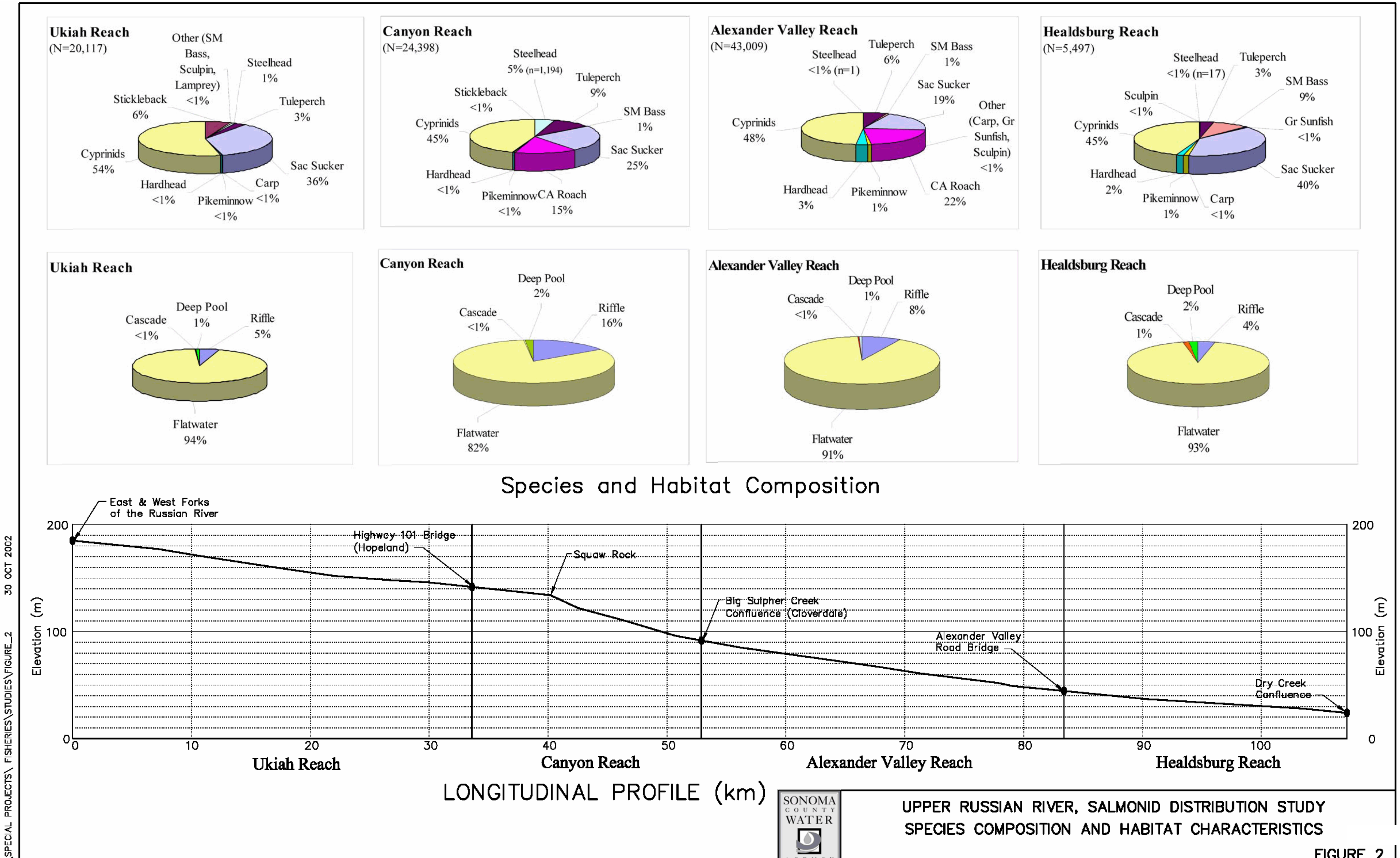

Figure 2-7 Russian River Mainstem Species Composition and Habitat Characteristics (Cook 2003)

Chinook salmon and steelhead smolt emigration provide information relevant to the status of listed fish species in the Russian River. This program is described briefly below.

Smolt Emigration

The objective of this sampling program is to collect information on wild salmonid smolts emigrating through the study reach.

<u>Methods</u>

A passive sampling methodology (rotary screw trap) was used to capture fish as they migrated past the trapping site (located approximately 60 meters downstream of the inflatable dam). Rotary screw fish traps are designed to capture downstream migrating juvenile fish.

Two sizes of rotary screw traps were operated during the 1999 to 2002 sampling seasons: an 8-foot-diameter trap was used prior to inflation of the dam, and one or two 5-foot-diameter traps (depending on flow conditions) were used after the dam was inflated. During the 2002 sampling season, one 8-foot-diameter trap and two 5-foot-diameter traps were operated concurrently throughout the trapping season. Table 2-9 summarizes the dates of operation of the rotary screw traps and the dates of operation of the inflatable dam for 1999 to 2002.

A mark-recapture study was conducted in 2001 and 2002 to estimate the number of Chinook salmon smolts migrating past the dam. Trapping began after the Chinook salmon run had begun in 2001; therefore, the numbers presented do not represent a seasonal total. Trapping began at the start of the emigration period in 2002, although the mark recapture phase of the study was delayed until the average size of Chinook salmon exceeded 60 mm FL.

Trapping data provided information on species composition and timing of emigration past the inflatable dam. Trapping also allowed for the collection of size and age data, and allowed for the collection of tissue for DNA sequencing. Variations in study conditions (such as the number of days of trapping and river discharge) do not allow a comparison of juvenile counts between years.

Table 2-9 Dates of Operation of Rotary Screw Trap, 1999 to 2002

1999														
April														
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
May														
1	2	3	4	5	6	7	8	9	10	11	12	13[1]	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

One 8-foot-diameter trap in operation.

One 5-foot-diameter trap in operation.

[1] Dam inflated on May 13, 1999.

2000														
April														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
May														
1	2[1]	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
June														
31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

One 8-foot-diameter trap in operation.

One 5-foot-diameter trap in operation April 25 – May 2, 2000.

Two 5-foot-diameter traps in operation May 2 – June 29, 2000.

[1] Dam inflated on May 2, 2000.

Table 2-9 Dates of Operation of Rotary Screw Trap, 1999 to 2002 (Continued)

2001														
April														
16	**17**	**18**	**19**	**20**	**21**	**22**[1]	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
May														
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
June														
31	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Two 5-foot-diameter traps in operation between the afternoon of April 19, 2001 and June 7, 2001. Traps were not operated on April 22, May 28, or May 29 due to insufficient flows.

[1] Dam inflated on April 22, 2001.

2002														
March														
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
April														
31	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
15	**16**[1]	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
30														
May														
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
June														
31	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
15	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**

Traps installed the afternoon of February 28, 2002. One 8-foot-diameter trap and two 5-foot-diameter traps operated concurrently through April 23, 2002.

[1] Dam inflated on April 16, 2002.

Results

Results of the trapping data are presented in Table 2-10.

Table 2-10 Juvenile Salmonids Captured in the Rotary Screw Traps, 1999 to 2002

Species	1999[1]	2000[2]	2001[3]	2002[4]
Wild Steelhead – Smolts	107	134	53	250
Wild Steelhead – Young-of-the-Year	69	763	150	5,843
Wild Chinook Salmon – Smolts	193	1,361	3,722	19,319
Hatchery Steelhead – Smolts	31	68	8	1,825

1 Traps operated for 19 days between April 21 and May 29, 1999.
2 Traps operated for 81 days between April 7 and June 29, 2000.
3 Traps operated for 46 days between April 19 and June 7, 2001.
4 Traps operated between March 1 and June 27, 2002.

The number of wild smolts is substantially greater than the count of hatchery smolts in 1999 to 2001, while the number of hatchery smolts is substantially greater than the count of wild smolts in 2002. This is a reflection of the study period. In years 1999 to 2001, the study period occurred primarily after the latest (mid-April) release dates of hatchery smolts, but in 2002 the study period began on March 1 and was within the period of hatchery releases. The substantial numbers of YOY steelhead may be associated with high tributary flow conditions, which may indicate that some spawning and juvenile rearing occurs in the lower and middle mainstem (in which case survival may be low), or may indicate that steelhead fingerling migrate to rearing areas in the Estuary.

1999 Sampling Season Results and Significant Findings

During the 19 days of sampling (between April 21 and May 29, 1999), a total of 193 Chinook salmon smolts, 107 wild steelhead smolts, and 69 wild steelhead YOY were captured in the rotary screw traps (Table 2-10). Although the data collected in 1999 were limited due to the intermittent sampling schedule, the study marked the first time that Chinook salmon smolts were captured in the river in significant numbers. The results of the 1999 sampling effort redirected the focus of the trapping study to include the collection of basic life-history data on Chinook salmon smolts in addition to assessing the effects of the dam on steelhead emigration.

2000 Sampling Season Results and Significant Findings

A total of 1,361 Chinook salmon smolts were captured between April 8 and June 28, 2000. The number of Chinook salmon smolts captured daily remained high through May and rapidly declined during the last 2 weeks of June. Although the start of the Chinook salmon smolt emigration period could not be determined from the data collected in 2000, the emigration period extended (at a very low level) through June.

A total of 134 steelhead smolts were captured throughout the 2000 trapping season.

Steelhead smolts were captured primarily in April and May, with low numbers of wild smolts captured through mid-June.

A total of 763 wild steelhead YOY were captured from April 10 through June 29, 2000. The large number of observed steelhead YOY may indicate that suitable spawning habitat is present in the mainstem Russian River in the vicinity of the inflatable dam. It is also possible that the YOY were washed out of upstream (mainstem and tributary) spawning habitat by a storm on April 16. Although comprehensive habitat surveys have not been conducted in the Wohler Pool vicinity, SCWA fisheries biologists have not observed suitable spawning substrate during monitoring activities in the Wohler Pool.

A few steelhead YOY were also captured in the Wohler Pool during August electrofishing surveys. These fish were generally larger than similar aged steelhead captured in Mark West and Santa Rosa creeks during fall surveys conducted by SCWA. The larger size suggests that some of these YOY were rearing in the mainstem river in the vicinity of the Wohler Pool. However, it is also possible that the YOY captured during boat electrofishing surveys drifted downstream from more upstream mainstem rearing habitat.

<u>2001 Sampling Season Results and Significant Findings</u>

In 2001, the river configuration below the dam changed, resulting in improved trapping conditions. Prior to 2001, the river channel below the dam was relatively uniform in depth across the channel with no discernable thalweg. In 2001, a small island formed in the middle of the channel, resulting in a split channel with the flows being concentrated along shorelines at both moderate and low flows. This channel configuration resulted in two well-defined thalwegs that concentrated emigrating fish and greatly improved trapping efficiencies over the previous years.

During the 46 days of sampling conducted between April 19 and June 7, 2001, 3,722 Chinook salmon smolts, 53 wild steelhead smolts, and 150 wild steelhead YOY were captured in the rotary screw traps (Table 2-10). A mark-recapture study was conducted for Chinook salmon from May 3 through June 5, 2001. Estimates of smolt emigration past the trap ranged from 18,511 using the weekly capture efficiencies to 20,341 using the seasonal capture efficiency. During the 5-week mark-recapture study period, 2,314 Chinook salmon smolts were actually caught. The estimates presented do not represent a seasonal estimate of smolt abundance since the first part of the emigration period was not sampled.

<u>2002 Sampling Season Results</u>

The rotary screw traps were deployed on February 28, 2002. During the period of sampling between March 1 and June 27, 2002, a total of 19,319 wild Chinook salmon smolts, 250 wild steelhead smolts, and 5,843 wild steelhead YOY were captured in the rotary screw traps (Table 2-10). Increased numbers of salmonids captured in the screw traps in 2002 may be due in part to increased trap efficiency (one 8-foot-diameter trap and two 5-foot-diameter traps were operated concurrently throughout the trapping season), and may also be associated with yearly population variability. The large number of steelhead YOY observed in 2002 (as in 2000) suggests that steelhead spawn and rear in the mainstem Russian River.

In 2002, the beginning of the smolt emigration period was sampled for the first time. Chinook salmon smolts were first captured in the trap on March 1, 2002 (three fry averaged 38 mm FL). Numbers and size of fish slowly increased in March and April, and numbers peaked in late April/early May. A mark-recapture study was initiated on March 26. Based on recapture rates and estimated trap efficiency, 215,875 Chinook salmon smolts were estimated to have emigrated through the study area between March 26 and June 9.

Adult Upstream Migration and Juvenile Migration through Fish Ladders

The main objective of video monitoring is to verify that anadromous fish are able to ascend the Denil fish ladders that provide access past the dam. A secondary objective assessed the timing of migration and relative numbers of anadromous fish utilizing the fish ladders while the dam was inflated. Monitoring of upstream migration was conducted only while the dam was in operation.

Video Monitoring Methods

Two study methods were employed to evaluate fish passage through the fish ladders. Time-lapse video photography was used to document fish passage through the fish ladders, and direct (snorkel) observations were conducted in 1999 to 2001 to determine whether large numbers of salmonids were holding below the dam. Snorkel surveys were of limited use during higher flows due to poor visibility and safety concerns in the area below the dam. At lower flows, snorkel surveys were effective in verifying that significant numbers of adult fish were not holding below the dam.

Underwater video cameras were located at the top of the ladders. The cameras generally recorded the movement of adult fish through the ladders 24 hours per day throughout the time period that the dam was inflated. When the dam was deflated, the fish ladders became inoperable; thus, the cameras were pulled at that time. Table 2-11 summarizes the dates of video monitoring for 1999 to 2002. Video monitoring was continuous throughout the study period, with a few exceptions (e.g., short-term system malfunctions).

In 1999 and 2000, monitoring began in May, soon after the dam was inflated. In 2001, monitoring was initiated in August (although the dam was inflated on April 22, 2001) because results of 1999 to 2000 monitoring indicated that adult salmonids were rarely using the fish ladders prior to August. In addition, monitoring conducted in 2000 continued through early January because conditions required the dam to be in operation longer.

Table 2-11 Dates of Video Monitoring, 1999 to 2002

Study Year	Date Dam Inflated	Date Dam Deflated	Dates of Video Monitoring
1999	May 13	Nov 14	May 20 – November 16
2000	May 2	Jan 10	May 12 – January 10
2001	April 22	Nov 13	August 7 – November 13
2002	April 16	Dec 11	August 6 – December 10

Video Monitoring Results, 1999 to 2002

Operation of the dam and fish ladders generally occurs between May and November, which coincides with a portion of the Chinook salmon migration period. (Chinook salmon migrate upstream primarily from September through December.) Steelhead and coho salmon begin their upstream migrations later in the year, often after the dam is removed, and are therefore less likely to be observed during video monitoring.

Species observed entering the fish ladders included Chinook salmon, chum salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, and white catfish. Most of the non-anadromous species were noted as "milling" in the exit boxes, as opposed to migrating upstream or downstream through the fish ladders. Detailed counts were made of anadromous fish and large cyprinids (potential predators) only. Observations of Chinook salmon and steelhead are described below. Adult coho salmon were not identified during video monitoring.

Chinook Salmon Results

Table 2-12 summarizes monthly counts of adult Chinook salmon observed migrating through the existing adult ladders at the inflatable dam during the 1999 to 2002 study seasons based on video monitoring.

Although only a fraction of the Chinook salmon migration was monitored in 1999, adult Chinook salmon were observed migrating through the fish ladders in numbers larger than previously believed to exist in the river. Chinook salmon were first observed in the fish ladder on August 26, 1999, but the majority was counted between October 27 and October 30.

In 2000, the entire Chinook salmon run was monitored for the first time. A total of 1,322 Chinook salmon were identified with an estimated run of 1,500 fish migrating above the dam. The Chinook salmon run began in early September, peaked in late November, and ended in late December.

Table 2-12 Monthly Counts[1] of Adult Chinook Salmon Observed Migrating through the Inflatable Dam Fish Passage Facilities, 1999 to 2002

Date	1999	2000	2001	2002
May	0	0	--	--
June	0	0	--	--
July	0	0	--	--
August	1	1	1	9
September	12 (3)	88 (5)	25	176
October	145 (76)	670 (63)	759 (10)	2,329
November	47 (12)	492 (51)	514 (74)	2,889
December	--	71 (37)	--	63
January	--	0	--	--
Totals	**205 (91)**	**1,322 (156)**	**1,299 (84)**	**5,466 (9)**

[1] Numbers in parentheses are salmonids that could not be positively identified, but based on timing and percentages of fish that were identified, were likely Chinook salmon.

A partial run count of 1,299 adult Chinook salmon through November 13, 2001, which may have occurred prior to the peak of the run, suggests the 2001 run may have been higher. Fish were still being counted when the dam was deflated, indicating that the run continued beyond the study period.

Between August 8 and December 10, 2002, a total of 5,466 adult Chinook salmon were observed. Substantial numbers of Chinook salmon were observed in early October, but the largest peak numbers occurred in early November.

Average daily water temperatures during the 2000 Chinook salmon migration ranged from 20.4°C on August 24 (date the first Chinook salmon was observed in the fish ladder) to 9.8°C during mid-November. The temperature on September 7 (the date that the run essentially began at the dam) was 19.5°C, and temperatures exceeded 20.0°C for 7 consecutive days in mid-September. Thirty-six Chinook salmon were observed in the fish ladder during this period. The weekly average water temperature was 14.7°C during the peak of the Chinook salmon migration period (last week of October).

Adult Steelhead Results

Winter-run adult steelhead migrate to their spawning grounds from November through June, typically peaking between December and March. The dam is seldom inflated during much of this time period; as a result, most of the steelhead spawning migration occurs outside of the sampling period. The number of steelhead recorded in the fish ladders represents only those fish migrating when the dam was inflated, and cannot be used as an estimate of steelhead abundance. Steelhead were divided into three categories: wild fish (possessing an adipose fin), hatchery fish (adipose fin clearly clipped), and unknown origin (could not be clearly determined if the adipose fin was clipped or not).

Adult steelhead were not observed in the fish ladders during the 1999 or 2001 sampling seasons. A total of 532 adult steelhead were observed in the fish ladders between May 15, 2000 and January 10, 2001 (consisting of 110 wild steelhead, 252 hatchery steelhead, and 170 steelhead of unknown origin). Adult steelhead were observed in the fish ladder in every month that the cameras were operated, except August and September. The run of wild adult steelhead above the dam was completed prior to the installation of the video cameras on May 6, 2000. After this date, four adult steelhead were identified as being wild. The numbers of steelhead identified in the ladders slowly increased during November, with relatively large numbers of steelhead migrating through the fish ladder beginning in December.

Steelhead were observed migrating upstream through the fish ladders at streamflows similar to those discussed for Chinook salmon. Adult steelhead were observed in the fish ladders when average daily temperatures exceeded 20.0°C on several occasions during the spring and early summer, with one fish ascending the ladder when the average daily temperature exceeded 24°C. However, water temperatures during mid-November when the upstream migration began in earnest ranged from approximately 10.0°C to 12.0°C.

Juvenile Steelhead Results

Wild and hatchery smolts, and smolts of undetermined origin, were observed passing through the fish ladder throughout the study. In addition, several steelhead smolts were observed entering the exit boxes, "milling," and leaving the box in the same direction from which they originally entered. Since it was possible that at least some of the observations were the same fish passing upstream and downstream repeatedly through the boxes, it was not possible to estimate the number of fish moving past the dam during any study year. However, observation of juvenile steelhead indicates that at least a few juvenile steelhead inhabit the Russian River in the vicinity of the Mirabel inflatable dam throughout the summer.

2.2.5 GENETIC VARIANCE IN COHO SALMON, STEELHEAD, AND CHINOOK SALMON

A key feature of the ESU concept is conservation of genetic resources that represent the evolutionary legacy of a biological species (Waples 1996). The ESA mandates the restoration of listed species in their natural habitats to a level at which they can sustain themselves without further legal protection, so NOAA Fisheries focuses on protecting naturally-spawning populations. The ESA recognizes that conservation of listed species may be facilitated by artificial means (Hard et al. 1992). Information on the genetic variance within and between naturally and artificially spawned populations is used to develop recovery programs and assess their effects on conservation of genetic resources within the Russian River basin.

Early work based on protein electrophoresis has formed an important basis for identification of salmon and trout population structure for management and conservation. Protein electrophoresis detects variation (allozymes) for a portion of the genome, the one that codes functional proteins.

Much of the recent genetic data are based on DNA analysis. Analysis of nuclear DNA (e.g., microsatellite DNA) detects differences at a more fundamental level—the nucleotide sequence—and therefore may potentially resolve smaller genetic differences between populations and individuals. Only minute amounts of tissue are needed for microsatellite (or mitochondrial [mtDNA]) analysis and this enables the use of nonlethal sampling methods on endangered and threatened fish. Alleles are different forms of a gene at a single gene locus. For example, a gene in an individual may contain one allele that codes for blue eyes and one for brown eyes. Allelic differences are used to measure genetic variation.

Genetic differences accumulate between populations that are strongly reproductively isolated from each other because gene flow is substantially reduced. Mutation and random genetic drift in isolated populations cause genetic differences to accumulate. These differences are used to measure the relative degree of reproductive isolation between populations (genetic distance) and to create phylogenetic trees that illustrate the relationships between populations and groups of populations. These genetic relationships can be compared to geographic distances to see if they are correlated. Fish are more likely to stray (resulting in gene flow between populations) between streams that are geographically closer to each other. Alternatively, out-of-basin stock transfers may reduce genetic differences between populations, but disrupt beneficial local adaptations that have a genetic basis. The relative amounts of genetic diversity within (F_{IS}) and between (F_{ST}) populations, which can affect the ability of a species to persist over the long term, can be quantified.

This section summarizes information on the genetic variance of coho salmon, steelhead, and Chinook salmon.

2.2.5.1 Coho Salmon

NOAA Fisheries (NMFS 1995) examined the genetic relationships of California and southern Oregon coho salmon populations by combining allozyme data from NOAA Fisheries samples with data from Olin (1984) and Gall et al. (1992). Two major geographic clusters were apparent and separated by a relatively large genetic distance (D = 0.126[2]). The northern, primarily large river group (within the Southern Oregon/Northern California Coast ESU directly to the north), included samples from the Elk River (near Cape Blanco) to the Eel River (just north of Cape Mendocino). The southern, primarily small river group, included nine samples from Fort Bragg to Tomales Bay (Lagunitas Creek), as well as three samples from north of Cape Mendocino. Considerable genetic diversity among populations was apparent within both groups.

The Willow Creek sample from the Russian River clustered with the Huckleberry Creek sample from the South Fork Eel River, but not with other creeks in the Eel River, which were more closely related to rivers to the north. Willow Creek clustered loosely with other proximate streams such as Lagunitas, Navarro, or Russian Gulch.

The Bodega Marine Laboratory (BML) used nuclear DNA to document coho salmon population diversity within the CCC ESU, with a special emphasis on the Russian River

[2]Cavalli-Sforza and Edwards (1967) Chord distance (D) was used.

basin (Hedgecock et al. 2003). Low numbers of spawners in the Russian River watershed have resulted in extensive reliance on the sampling of juveniles, so molecular markers were developed to distinguish coho salmon from Chinook salmon and steelhead.

The BML study generally supported the California ESU structure, which includes the CCC, the South of San Francisco ESU recognized by California's ESA, and the Eel and Mattole River samples from the Southern Oregon/Northern California ESU. However, even after the genetic tree was adjusted for admixture and family structure, the node separating the South of San Francisco ESU and a large proportion of the CCC ESU was not supported. Green Valley Creek in the Russian River watershed and Redwood Creek in Marin County were outliers in the genetic tree.

Russian River Basin Samples

Coho salmon from the Russian River watershed and from streams in Marin County were collected for the Russian River coho salmon captive broodstock program. Results of the BML study and of genetic research at the NOAA Fisheries South West Science Center, Santa Cruz Laboratory (NOAA Fisheries Santa Cruz Laboratory) are being used to assess the genetic diversity of these populations and to identify suitable source populations for the captive broodstock program.

Juvenile samples from Green Valley Creek from 1997, 1998, and 2000 were assessed for their level of inbreeding and compared to samples from hatchery populations and from other watersheds within the ESU (Hedgecock et al. 2003). The Green Valley 1998 samples had high levels of inbreeding. The effective number of breeders in this tributary was estimated as 10, which suggests this population has undergone a population bottleneck and may be subject to a substantial amount of genetic drift. The study concluded the risk of inbreeding in the coho salmon captive broodstock program would be high if Green Valley Creek fish were used or were not interbred with populations from a neighboring watershed (such as Lagunitas or Olema creeks). The Green Valley samples were also very different from Russian River hatchery samples. The homogeneity of samples from Lagunitas Creek (in Marin County) from different year classes and tributaries was found to contrast with the heterogeneity of samples in other drainages. Stocking history, which could influence the relationships between populations, was not researched for Lagunitas Creek.

Samples from Green Valley Creek were distant from other populations. The samples collected in 2002, which were the most distant, were very different from Lagunitas (F_{ST} values[3] of 0.101 to 0.109) and Olema (F_{ST} 0.132 to 0.134), suggesting that there could be a substantial risk of outbreeding depression if these populations were interbred. (Outbreeding depression is the phenomenon of decreased fitness following hybridization of individuals from populations with divergent genetic composition, which can occur when out-of-basin stocks are used in a hatchery program. Coadapted gene complexes may be disrupted or local adaptations can be lost.) Additional samples evaluated by the

[3]F statistics (Wright 1931, 1943) measure the average genetic correlations between populations. An F_{ST}=1.0 between two populations indicates very divergent populations.

NOAA Fisheries Santa Cruz Laboratory showed that Green Valley fish collected for the captive broodstock program were closely related to fish collected from two other watersheds in the Russian River (Mark West and Maaccama creeks). This indicates that a unique Russian River basin stock that is not closely related to the Lagunitas and Olema creek populations or to coho salmon stocked in the past by the DCFH, may currently exist (Garza and Gilbert-Horvath 2003). A large number of alleles present in Russian River populations but not in Lagunitas populations suggest that the Russian River populations may have local adaptations. Interbreeding of the two populations could cause significant outbreeding depression and therefore was not recommended (Garza and Gilbert Horvath 2003).

The NOAA Fisheries Santa Cruz Laboratory is undertaking a comprehensive genetic assessment of population structure and demography for coastal populations of coho salmon in central California, and will develop baseline genetic information for use in future monitoring and propagation efforts. The research project is designed to evaluate and document differences between the genetic composition of wild fish and artificially introduced fish. The laboratory is analyzing tissue samples from coho salmon collected for the captive broodstock program at DCFH to develop a mating scheme. These data are being used to evaluate the relative risks between inbreeding and outbreeding depression as the capture, mating, and release protocols are developed for the captive broodstock program.

2.2.5.2 Steelhead

Allozyme studies presented in Busby et al. (1996) show a great deal of genetic variability among populations of this ESU. Samples from Coleman National Fish Hatchery and two tributaries in the Sacramento River Basin cluster distinctly from other steelhead in this ESU. Another cluster includes streams from this ESU (Lagunitas, Scott, San Lorenzo, Alameda, Arroyo Hondo, and Gaviota) but also includes the Ten Mile River sample in Mendocino County north of the Russian River, and Whale Rock near San Luis Obispo in southern California. An anomalous geographic structure was detected in this allozyme study. Though modest differences were found between samples from Ten Mile River and Lagunitas Creek, these samples were also found to be more similar to the Whale Rock Hatchery (near San Luis Obispo) samples than to populations geographically closer (Scott Creek and San Lorenzo). Nielsen (1994) found substantial differences in frequencies of some mtDNA alleles between Mendocino and Marin County samples, but the Ten Mile River and Lagunitas Creek allozyme data did not reflect this, as seen by their relative similarity.

Nielsen (1994) included Russian River samples in a study that found biogeographic distribution of mitochondrial and nuclear DNA in naturally-spawning coastal steelhead in California. Data for both mtDNA and a single microsatellite locus (Omy77) gave significant differentiation between three broad bioregions: north coast, central coast (Russian River to Point Sur), and south coast. Six steelhead hatchery populations (Van Arsdale Hatchery on the Eel River, Van Duzen River Hatchery, DCFH on the Russian River, Big Creek Hatchery near Scott Creek, San Lorenzo River hatchery in Santa Cruz, and Whale Rock Hatchery near Morro Bay in southern California) did not show significant biogeographic structuring of mtDNA genotypes, but were dominated by mtDNA types that were most common in their general geographic area. Similarly, no significant biogeographic association with Omy77 was detected.

In a study that compared hatchery stocks and geographically proximate populations of anadromous salmonids, hatchery stocks of steelhead carried significantly more mtDNA types than geographically proximate wild populations (Table 2-13) (Nielsen 1994). The authors suggest that the abundance of these rare mtDNA types in hatchery stocks may be due to historic stock transfers that introduced divergent lineages into hatchery stocks.

Table 2-13 The Number of *O. mykiss* mtDNA Types Found Only in Wild or Hatchery Populations in Paired Comparisons of Geographically Proximate Populations, Based on Fish Sampled from 1990 to 1993 (Nielsen, Gan, and Thomas 1994)

Location	Number of mtDNA Types	
	Wild Only	Hatchery Only
Eel River	0	3
Russian River	1	2
Big Creek Hatchery	0	3
Whale Rock Hatchery	1	2
Total	**2**	**10**

The NOAA Fisheries Santa Cruz Laboratory is conducting further analysis of the genetic structure of coastal populations of steelhead. A study is also underway to compare steelhead populations upstream and downstream of ten impassable barriers in the Russian River, and to conduct a phylogenetic analysis within the Russian River watershed (Deiner et al. 2002). Preliminary review of data from populations above and below a passage barrier on Mill Creek found differences between the populations and found unique alleles in the population above the barrier.

2.2.5.3 Chinook Salmon

As discussed in Section 2.2.3.3, the size of the historical Chinook salmon population in the Russian River is unknown. Current monitoring programs such as data from the inflatable dam monitoring program have documented a naturally-spawning population in recent years, despite the suspension of hatchery production in 1999 (Chase et al. 2001, 2002, 2003). Given the high level of interbasin transfers over many years, and that the sources of many of the Chinook salmon planted were streams in what are now considered separate ESUs, naturally-spawning Chinook salmon within the river may represent a genetic conglomerate of many stocks. Data, however, are unavailable to quantify the degree of introgression. Similarly, adults used as broodstock may themselves be descendants of many stocks. Historically, substantial stocking of Sacramento River

Chinook salmon into the Russian River has occurred and could have contributed to the current genetic stock structure. Klamath River stocks have also been introduced.

Out-of-basin stocks were planted in the Russian River through 1998. Historically, a large percentage of Chinook salmon planted in the Russian River were from the Sacramento River (38 percent). Several runs of Chinook salmon are found in the Sacramento and San Joaquin rivers (in the California Central Valley ESUs), including spring-, fall-, and late fall-run. The Central Valley historically contained predominantly spring-run fish, but fall-run are currently the most numerous.

Coastal Chinook Salmon Differentiation

Coastal Chinook salmon populations south of Cape Blanco, Oregon, are substantially different morphologically and physiologically from populations to the north. Moreover, there is finer scale differentiation between shorter coastal systems and the two larger river basins, the Rogue and Klamath rivers (Myers et al. 1998).

In a recent study in the Chinook salmon status review (Myers et al. 1998), allelic frequencies for 29 to 31 loci collected over 15 years by researchers at NOAA Fisheries, University of California at Davis, Washington Department of Fish and Wildlife (WDFW), and the Alaska Department of Fish and Game (ADFG) were pooled. A total of 193 populations from Alaska to California were analyzed. A clear separation of populations with ocean-type and stream-type life-histories was found. Several distinct subclusters appear among ocean-type samples, including: 1) the British Columbia and Puget Sound rivers, 2) coastal rivers of Washington, Oregon, and California, 3) Upper Klamath River samples, 4) the Columbia River basin, and 5) the Sacramento-San Joaquin River drainage.

The population structure suggested in this status review (Myers et al. 1998) is mostly consistent with previous studies. A California coastal group comprising populations south of the Klamath River, were consistent with Bartley and Gall (1990) and Bartley et al. (1992, cited in Myers et al. 1998). Sacramento-San Joaquin River populations were distinct, and DNA data indicated that winter-, spring-, fall-, and late fall-runs were genetically distinct (Hedgecock et al. 1995; Banks et al. 1996; and Nielsen 1995, 1997).

In addition to the Sacramento River, the Klamath River has been historically a source of Chinook salmon plants into the Russian River (11 percent). Banks et al. (1999) used five microsatellite loci to look at population structure for 11 fall- and spring-run Chinook salmon samples in the Klamath River and compared these samples to Chinook salmon in the Central Valley. Two large clusters in the Klamath River basin populations differed from Central Valley populations. The upstream-most populations in the Klamath River basin (Scott River, Shasta River, and Iron Gate Hatchery) were differentiated from subclusters of fall- and spring-run subclusters in the Trinity and Salmon rivers. The Blue Creek population (from the lower Klamath River) was more similar to southern Oregon and California coastal Chinook salmon populations than to upper Klamath/Trinity River populations.

Additional genetic data analyzed for a Chinook salmon status review update (Busby et al. 1999) helped delineate the California Coastal Chinook ESU (NMFS 1999c). In 1998 and 1999, NOAA Fisheries, CDFG, USFWS, and the U.S. Forest Service collected samples from adult Chinook salmon from 13 rivers and hatcheries in the Central Valley and Klamath River basin, and analyzed them along with allozyme data for California and southern Oregon Chinook salmon used in Myers et al. (1998). The population structure in this analysis was consistent with the major genetic groups found in previous studies (Utter et al. 1989; Gall et al. 1992; Myers et al. 1998, cited in NMFS 1999c). The Central Valley group was the most divergent. The remaining samples formed two large groups that included samples from the Klamath River basin and from coastal rivers. Blue Creek clustered with the coastal samples. The coastal river samples contained two subclusters from rivers south and north of the Klamath River. The genetic distances between these two subclusters corresponded roughly to the differences found between Central Valley spring-, fall-, and late fall-run Chinook ESUs, and the Washington and Oregon coast Chinook ESUs.

MtDNA haplotypes from some fall-run Chinook salmon smolts captured in 1993 and 1994 from the Russian River Estuary did not match haplotypes from the DCFH, and a rare haplotype was found only in Chinook salmon from the Russian and Guadalupe rivers (Nielsen 1994, cited in Busby et al. 1999). Significant haplotype frequency differences between Guadalupe River Chinook salmon and the four spawning runs in the Central Valley were primarily due to the rare haplotype found in two fish in the Guadalupe River but not found in the Central Valley. (The remaining 27 samples from the Guadalupe River were indistinguishable from the Merced River and Feather River hatchery samples.) However, when samples from the Sacramento River drainage and the Guadalupe River from 1991 to 1995 were analyzed, one fish from the 1994 fall-run Coleman Hatchery carried a haplotype previously found only in the 1994 collection from the Guadalupe River, suggesting this stock may be the source of the unique Chinook salmon haplotypes found in the Guadalupe River in 1993 to 1994 (Nielsen 1997).

Genetic studies to date suggest that coastal stocks within the California Coastal Chinook ESU are distinct from stocks in neighboring ESUs. Rare mtDNA haploytypes found in the Russian and the Guadalupe rivers (in separate ESUs) may have been the result of hatchery strays.

Genetic samples collected from naturally produced Chinook salmon juveniles in the Russian River by SCWA in 1999 have been analyzed by the BML to assess their affinity with other coastal Chinook salmon populations (Hedgecock et al. 2003). Samples from Chinook salmon in the Russian River (collected from Forsythe Creek and the inflatable dam area where Chinook salmon migrate through) were compared with samples from the Eel, Klamath, and Trinity rivers, DCFH (two sample sets derived from Eel River stocks), Central Valley, and Santa Clara Valley. No correction for family structure was necessary because samples did not have high levels of linkage disequilibrium. Chinook salmon in the Santa Clara Valley and Central Valley stocks (inland stocks) were closely related. Based on seven loci, coastal Chinook salmon from the Eel, Russian, and Klamath rivers clustered on one side of the dendogram while the inland populations clustered on the other side of the dendogram, which indicates they are genetically different. The Eel and

Russian rivers cluster together, but are distinct from one another with a bootstrap value of 919,[4] which indicates they are genetically distinct. These data indicate Chinook salmon from the Russian River were not closely related to Central Valley or Eel River populations. The report concluded that Chinook salmon in the Russian River belong to a diverse set of coastal Chinook salmon populations.

2.2.6 Salmonid Predators

Figure 2-6 shows the species composition found during snorkel surveys conducted in the Russian River mainstem in summer and fall of 2002 (Cook 2003b). Cyprinids and Sacramento suckers dominated most of the observed fish communities. Juvenile cyprinids (California roach, pikeminnow, and hardhead) can be difficult to distinguish and were identified to family when species identification was not possible. Although population estimates are not available, these surveys show that native and non-native species that could potentially compete with or prey upon juvenile salmonids were present throughout the watershed.

Data collected in 2000, 2001, and 2002 during electrofishing sampling (as part of SCWA's inflatable dam/Wohler Pool Fish Sampling Program) indicated that three potential salmonid predators inhabit the Russian River near the inflatable dam: Sacramento pikeminnow, smallmouth bass, and largemouth bass (Chase et al. 2001). Two large striped bass have been captured in 4 years of sampling, and two others have been observed during video monitoring and snorkel surveys, although, in general, not many have been seen. Adults of each of these species may prey upon juvenile salmonids. However, electrofishing sampling data from 1999 through 2002 indicate that the pikeminnow, smallmouth bass, and largemouth bass populations in the vicinity of the inflatable dam are composed predominantly of juveniles. For example, in 2000, 40 percent (1,349) of all fish captured during SCWA's inflatable dam/Wohler Pool Fish Sampling Program fell in the predatory category. Eighty-five percent (1,148) of the predators captured were YOY, and only 2.6 percent (35) of the predators were Age 2+ or older (i.e., large enough to prey on juvenile salmonids). Results from SCWA's 1999 sampling showed a similar predominance of juvenile fish (Chase et al. 2000).

The following sections briefly describe the life-history, habitat, and occurrence of each of these potential predatory species in the Russian River.

2.2.6.1 Sacramento Pikeminnow

The Sacramento pikeminnow is native to the Russian River (Moyle 2002). Site-specific information on pikeminnow in the Russian River is limited, and most of what is known their biology and life-history comes from studies conducted in other river systems, primarily in the Sacramento and San Joaquin rivers. This species occupies pools throughout the Russian River and the lower reaches of larger tributaries (Chase et al.

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[4]The significance of nodes in a phylogenetic tree is tested with bootstrap analysis, in which genetic distance is estimated by producing many trees (1,000 in this study). A node is considered significant if it is recovered in more than half of the bootstrap trees (500).

2001). However, estimates of pikeminnow abundance in the Russian River are not available. Sacramento pikeminnow was observed in low numbers (2.8 percent of the total captures) during SCWA electrofishing surveys conducted in August 2000 in the Wohler Pool area.

Pikeminnow prefer warmwater streams with abundant pools (Taft and Murphy 1950; Moyle and Nichols 1973). Pikeminnow generally prefer relatively low-velocity habitat (< 15 centimeters per second [cm/s]) except when foraging or moving from one pool to another, moderate depths (0.5 to 2.0 meters), and a substrate of gravel to boulder (Knight 1985).

Pikeminnow juveniles feed on aquatic insects, and, as they grow, switch to a diet primarily of fish (Moyle 2002). Adult Sacramento pikeminnow are known to eat salmon and steelhead smolts (Moyle 2002). Pikeminnow generally begin to include fish in their diet after reaching a length of 165 to 230 mm. A literature review conducted by SCWA staff found three size classes of pikeminnow in terms of the potential to prey on salmonids: pikeminnow that are less than 200 mm FL (where fish are an insignificant part of their diet); those between 200 and 300 mm FL (where fish comprise a small portion of their diet); and those greater than 300 mm FL (where fish comprise a significant part of their diet) (Chase et al. 2001).

2.2.6.2 Smallmouth Bass

Smallmouth bass are an introduced species and are widespread and abundant in the lower Russian River. Smallmouth bass appear to be widespread throughout the mainstem Russian River with peak abundances reportedly occurring in the Alexander Valley (Chase et al. 2001, Cook 2003a). Smallmouth bass was the most abundant species observed during SCWA electrofishing surveys conducted in August 2000 in the Wohler Pool, comprising 34.4 percent of the total captures (Chase et al. 2001).

Edwards et al. (1983) describe optimal habitat for smallmouth bass as cool, clear streams with abundant shade and cover. Smallmouth bass prefer deep, dark hiding areas with cover provided by boulders, stumps, rootwads, and large woody debris. Optimal water temperatures for growth range from 26 to 29°C, and preferred temperatures range from 21 to 27°C (data cited by Edwards et al. 1983; Carlander 1977). Growth reportedly does not occur at temperatures below 10°C to 14°C (data cited by Edwards et al. 1983; Carlander 1977).

Smallmouth bass will consume a wide variety of food items, including fish, crayfish, insects, and amphibians (Moyle 1976). Smallmouth bass have been documented to feed on salmonids, primarily under-yearling Chinook salmon smolts such as those found in the Russian River. Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by smallmouth bass between 200 and 400 mm FL. Based on this regression, a 200-mm smallmouth bass can consume a 100 mm salmonid. Smallmouth bass observed during SCWA electrofishing surveys ranged in size from 50 to 370 mm FL.

2.2.6.3 Largemouth Bass

Little data are available on the abundance and distribution of largemouth bass (an introduced species) in the Russian River. They are apparently confined to the lower sections of the river, but are generally not considered abundant. Largemouth bass were captured in low numbers (approximately 1 percent of the total captures) during SCWA's sampling in the Wohler Pool (Chase et al. 2001), but were not captured during a similar study conducted in 1999 (Chase et al. 2000). They were not observed during snorkel surveys in 2002 (Cook 2003a).

In rivers, largemouth bass prefer low-velocity habitats with aquatic vegetation (Stuber et al. 1982; Carlander 1977). Stuber et al. (1982) reviewed the literature on largemouth bass and concluded that optimal temperatures for growth of juvenile and adult largemouth bass range from 24°C to 36°C.

Largemouth bass feed primarily on fish and crayfish after reaching a size of 100 to 125 mm standard length (SL) (approximately 125 to 150 mm FL). The risk of largemouth bass predation on salmonids is low because their habitats seldom overlap. However, salmonids may become vulnerable to largemouth bass predation during the later half of the emigration period when streamflows decrease and water temperatures increase. Under these conditions, largemouth bass are more likely to become active. Largemouth bass will apparently consume any animal that it can fit in its mouth, including small mammals, waterfowl, frogs, and fish.